MECHANICAL ENGINEERING

INCLUDING THE ENGINEERING INDEX

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Two Splendid A.S.M.E. gatherings will be held at widely separated points this Spring. Keep the places and dates in mind, and plan to be present at one or both.

Providence, R. I., May 3-6, 1926

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MARCH 1926

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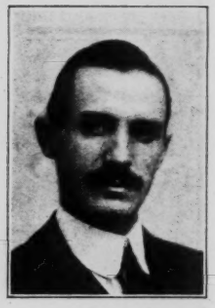

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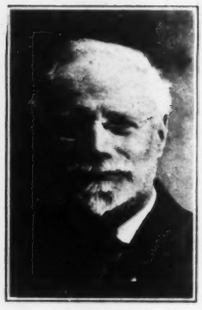

HERMANN LEMP

H. W. BROOKS

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* * * * *

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COMING A.S.M.E. MEETINGS

Providence, R. I., May 3–6—San Francisco, Cal., June 28–July 1

Keep the dates and places in mind as these will be two spendid meetings. The Providence Regional Meeting gives promise of an interesting four-day program while that at San Francisco is the regular Spring Meeting. For this meeting a special train will leave New York covering over 8000 miles on a sight-seeing tour to points of interest en route to and from San Francisco. See the current issues of the A.S.M.E. NEWS for details of the trip.

MECHANICAL ENGINEERING

Volume 48 March, 1926 No. 3

The Mechanical Engineering Curriculum

Summary of Replies to a Questionnaire Sent to 500 Members of the A.S.M.E. Indicating the Need for Particularly Sound Training in All Subjects Given, and for More Cultural and Elementary Scientific Subjects in the Usual Four-Year Course

By JOHN LYLE HARRINGTON,[1] KANSAS CITY, MO.

THE Society for the Promotion of Engineering Education, supported by the Carnegie Corporation, is conducting a three years' investigation into "the fitness of engineering curricula and teaching processes" to fulfill "the purposes and objects of engineering education." The specific training of youth for the profession of engineering is a comparatively recent development in higher institutions of learning, for, though colleges and universities, including schools for training the older professions, have existed substantially from the beginning of written history, the earliest engineering schools were organized but a century ago, and it is but a scant half-century since their establishment became general. They gradually emerged from the schools designed for academic education, and therefore naturally take the same general form and character. The first strictly technical subjects were few and general, but gradually, as engineering knowledge has been extended, the professional subjects have increased in number and the engineering courses have been divided, much as the profession has been divided in its own organization.

For a considerable period, practitioners urged upon the schools more and more technical work, until it was found substantially impossible to give the student, in the usual four years, even the most essential fundamentals and sufficient technical subjects to satisfy this demand. Consideration was given to lengthening the courses to five or six years, and, in a few instances, to requiring an academic degree before entering upon the technical studies. But realization of the fact that in general the student has not the time, means, or inclination to pursue courses more than four years in length has led to the general establishment of the four-year course for the training of engineers. A progress report by the Director of Investigation, Mr. W. E. Wickenden, shows close, general conformity of the technical schools to the average requirement for all courses of 1.74 academic years of preparatory training of the college character, 0.19 academic year of elective courses, 1.12 academic years of general technological training, and 1.06 years of special technological training, specifically in accord with the title of the courses in civil, mechanical, chemical, or mining and metallurgical engineering.

The investigation is following the general plan of gathering the "evidence to be derived from the experience of the colleges and their graduates," of taking "inventory of the occupational demands confronting the engineering colleges," of making "an inquiry into the bonds which exist and should exist between the engineering colleges and the organized life of the engineering professions," of considering "projects in the theory and technique of education and psychology," of investigating "engineering education in Europe," of considering "the requirements of representative engineering curricula, compared with the requirements in schools of law and medicine," and of endeavoring to determine "what is a profession and what does the term 'Professional Education' imply."

The S.P.E.E. Investigation of Engineering Education

The Society for the Promotion of Engineering Education invited the national societies in civil, mechanical, electrical, and mining and metallurgical engineering to appoint two counselors to advise with the Board of Investigation and Coördination, and the Board invited the executive secretaries of these societies to act with its members and counselors as a joint council on engineering education and professional life. Of the group involved, twelve represent the professional societies, eleven represent the colleges, and one acts in a dual capacity.

Under the direction of the Board, the faculties of the engineering schools have carried out studies of the engineering teaching personnel, of the engineering graduates and non-graduate former students, of the costs of engineering education, of engineering students at the time of entrance to college, of admissions and eliminations of engineering students, and of the entrance requirements and the graduate requirements of the engineering schools.

Questionnaire Sent to Members of the A.S.M.E.

To quote the Director of Investigation, "If the professional bodies are to look to the schools for sounder and broader training of future engineers, the schools may equally look to the societies for clearer definitions of the professional patterns which such training may be expected to follow," hence the views of the practicing engineers regarding the best training of the engineer to meet the demands of modern professional life have been sought by questionnaires, and it is the primary purpose of this discussion to present the results of such a questionnaire sent to five hundred members of The American Society of Mechanical Engineers, selected, as far as possible, for their broad understanding of the problems of the mechanical engineer. Approximately two hundred and fifty were in executive positions—presidents, vice-presidents, and managers of industrial corporations; and approximately two hundred and fifty were engaged chiefly in the strictly technical phases of the mechanical engineer's work. Consideration was not given to any particular line of work, but educators were substantially omitted from the list, since they were already taking an important part in the investigation, and the questionnaire was intended primarily to bring out the views of the practitioner. On the whole, we believe that the questionnaire has secured opinions closely in accord with the broad, general views of the members of the A.S.M.E.

Most of those to whom the questionnaire was sent were necessarily older members of the profession, those who had had broad experience and who had formed opinions regarding what should be the education of an engineer.

Of those responding to the questionnaire 62 per cent have degrees in mechanical engineering and approximately 80 per cent have degrees, while 20 per cent failed to state their degrees and are presumably without school training.

About 40 per cent are engaged in manufacturing, 15 per cent in consulting practice, 27 per cent in various other lines of technical work, and 18 per cent unstated.

The questionnaire was long, intricate, and difficult to answer; it required material sacrifice of time on the part of its recipients; but it was answered thoughtfully and fully by more than half of those to whom it was sent. So while the responses come from only about 260 members of the Society, or about one in sixty-eight of the membership, it is believed that the consensus of opinion expressed

[1] Harrington, Howard & Ash. Past-President A.S.M.E.

Report of A.S.M.E. Study of Mechanical Engineering Education presented at the Annual Meeting of The American Society of Mechanical Engineers, New York, Nov. 30 to Dec. 4, 1925.

in response to the questionnaire is substantially the true opinion of the mechanical engineer as he is represented in the Society.

The questionnaire presumed the general acceptance of the fundamental mathematics, English, physics, chemistry, drawing, and like subjects, and confined the inquiries to technical or related subjects.

SUBJECTS ESSENTIAL TO ALL MAJOR DIVISIONS OF ENGINEERING

The first inquiry was for opinions regarding fundamental elements of engineering courses, that is, the subjects essential to all the major divisions of engineering. The percentage of those favoring the individual subjects is as follows:

	Per cent
Mechanics	93
Mechanics of Materials	86.5
Elementary Electrical Engineering	84
Thermodynamics	66.5
Hydraulics	66
Shopwork	64.5
Economics	62.5
Management	55.7
Business Law	55.7
Accounting	52.8
Human Relations	51.5
Modern Languages	46
History	36.9

In the comment on this question much favorable attention is given to additional cultural subjects and additional instruction in the elemental sciences. Many stressed the value of a better knowledge of the English language, or more ability to speak and to write, and considerable comment favors further instruction in economics.

On the other hand, there is considerable comment unfavorable to instruction in economics and history, and rather general agreement unfavorable to instruction in human relations and management, for it is thought the lack of practical professional experience makes it impossible for the student to grasp these subjects.

Less than one-half those answering favored inclusion of modern languages in the course.

Considerable importance is placed upon the value of visits to plants and upon lectures by practicing engineers, and much emphasis is placed upon exceedingly thorough work in the fundamental technical courses, rather than a greater number of courses less well given.

SPECIALIZATION IN ENGINEERING EDUCATION

Question II deals with specialization in engineering education; 13.25 per cent of the answers favored sharply differentiated technical courses, while 71 per cent favored the broader general course, and about 15 per cent did not answer the question. It is to be expected that men who follow the strictly technical work should strongly favor a differentiated course, and that men who have had to deal with the business as well as the technical phases should favor the broader training. These tendencies are clearly evidenced in the responses, for a great number dwell at length upon the desirability of a broad, general education of sound training in the scientific method of attack of problems, and in leaving to the period of professional practice the greater development of the technical knowledge.

A considerable group recommend substantially the course now followed in our engineering schools, that is, the first two years to be devoted to mathematics, chemistry, physics, English, and similar academic subjects; the third year to the fundamental technical subjects, and the fourth year to specialized technical work. But the broader cultural and scientific foundation is generally favored.

The second part of Question II is an inquiry whether the general purpose of specialized mechanical-engineering subjects should be to prepare men for particular fields of work, or whether they should be only the media for the teaching of fundamental scientific principles and engineering methods. Twelve and six-tenths per cent of the answers favor preparation for the particular fields, while 68.7 per cent consider the subjects essentially as media for the teaching of scientific principles.

A considerable group favors the highly specialized technical work because it is best calculated to enable the graduate to earn at once a large compensation. But a number consider high specialization in a narrow field desirable, professionally as well as financially.

RELATIVE IMPORTANCE OF MECHANICAL-ENGINEERING SUBJECTS INCLUDED IN CURRICULUM

The first part of Question III requests opinions regarding the relative importance of the mechanical-engineering subjects which should be included in the training of all mechanical engineers. The subjects and the percentage of those favoring each follow:

	Per cent
Machine Design	77.5
Heat Power Engineering	68.7
Power-Plant Engineering	60
Industrial Engineering	46.5
Heating and Ventilation	45.2
Refrigeration	30.0
Railway Mechanical Engineering	13.4
Marine Engineering	7.1
Automobile Engineering	7.5
Ordnance	4.2
Textile-Mill Engineering	2.9
Aeronautical Engineering	2.5

In the comment on this question a few other subjects are suggested, but in general stress is laid upon the necessity for sound instruction in principles rather than in particular subjects.

The second half of Question III and the answers to it appear below:

> "In your opinion, which, if any, of the above divisions of mechanical engineering are of such importance as to warrant provision for distinct, complete courses, such as special courses in automotive engineering or marine engineering? Should these be given in all, many, or few institutions?"

		Per cent
Machine Design	All	3.34
	Many	0.84
	Few	5.45
Heat Power Engineering	All	2.5
	Many	0.84
	Few	6.28
Power-Plant Engineering	All	2.92
	Many	2.09
	Few	6.28
Heating and Ventilation	All	1.25
	Many	3.76
	Few	6.28
Industrial Engineering	All	1.25
	Many	3.76
	Few	7.55
Refrigeration	All	1.25
	Many	6.28
	Few	8.4
Railway Mechanical Engineering	All	0.84
	Many	6.28
	Few	15.5
Marine Engineering	All	0.84
	Many	7.55
	Few	18.9
Automobile Engineering	All	1.25
	Many	5.86
	Few	13.4
Ordnance	All	0.84
	Many	4.62
	Few	14.2
Textile-Mill Engineering	All	0.84
	Many	7.55
	Few	13.5
Aeronautical Engineering	All	0.84
	Many	7.55
	Few	17.6
Unclassified		39.4
Unstated—For the entire question		13.4

The comment contains the suggestion that specialized courses should somewhere be available to the student desiring them, generally as post-graduate courses given by only a few leading institutions.

The third division of Question III reads:

> "Do you, in general, feel that the need of industry and the profession would be better served by a relatively small number of courses in the major divisions of engineering, or by a rather considerable number of more

specialized courses from which a student could choose, and which would be designed to fit men for particular divisions of work?"

The answers are divided as follows:

	Per cent
Small number of courses	72.5
Large number of special courses	14.6
Unclassified	5.8
Unstated	7.1

By far the larger part of the comment agrees that the industry and the profession would be better served by relatively smaller number of courses in the major divisions of engineering, but a few hold the contrary opinion, and believe that the specialist is in demand, that the student should be required to make up his mind exactly what he wants and to devote himself to a narrow field.

THE BEST EDUCATIONAL PREPARATION FOR WORK IN ADMINISTRATION AND MANAGEMENT

The fourth question reads thus:

"That administration and management are vital factors and hence of major importance in the field of mechanical engineering, is generally recognized. Whether students of mechanical engineering should receive definite training for this work is not, however, so generally agreed upon. Do you think that the best preparation for this type of work is through sound courses in mechanical engineering with some attention to administration and management (possibly in the form of a subject of instruction given in the junior or senior year), or through special courses variously designated "Engineering Administration," "Industrial Engineering," and the like?

The following responses throw considerable light upon the judgment of engineers:

	Per cent
Sound courses in mechanical engineering	70.0
Special courses	15.0
Unclassified	7.1
Unstated	7.9

A large part of the comment is devoted to expression of the opinion that administration and management cannot be properly taught in college because the student is immature and without the practical experience to understand, and because the subjects would be academic by reason of the absence of contact with industry. There is considerable comment favorable to some general outline instruction in the subjects, chiefly by lectures given by men who are engaged in industry and are exercising the administrative or managerial functions.

ECONOMICS AND TRAINING IN BUSINESS PROCEDURES

The fifth question related to economics and training in business procedures. The three parts and the answers to them are as follows:

"Do you believe that the importance of the economic aspects of engineering work is such as to warrant much, moderate, or little emphasis in engineering courses?"

	Per cent
Much	39.0
Moderate	44.0
Little	7.0
Unclassified	0.42
Unstated	9.6

"Has your observation led you to believe that engineering graduates are as well, or not as well, qualified to deal with problems of a basically economic nature as they are to solve technical problems?"

	Per cent
As well	18.0
Not as well	71.0
Unstated	11.0

"A typical mechanical-engineering course includes one subject in general economics given by the department of economics of the institution, usually in the junior year, comprising two or three lectures and recitations per week for two terms. Do you believe that more work of this character is desirable, or that more emphasis should be given to the economic aspects of engineering in the teaching of the engineering subjects themselves?"

	Per cent
More work	10.0
More emphasis	47.8
Both	4.6
Sufficient	10.0
Unclassified	15.5
Unstated	12.1

The comment on this question is decidedly favorable to substantial instruction in economics, but questions the value of the subject as now generally taught. The belief is common that economics should be taught by an engineer or by an economist who has knowledge of engineering and the engineer's viewpoint.

FUNCTIONAL VS. TECHNICAL DIVISION OF COURSES IN MAJOR ENGINEERING FIELDS

Question VI relates to a plan of technical instruction suggested in a paper presented in June, 1924, to the Society for the Promotion of Engineering Education by Prof. Edward Bennett, of the University of Wisconsin, and which manifestly has some attractive features. The question and the responses follow.

"A new plant has been advocated which divides the courses in the major engineering fields into functional (research, design, administration, supervision, sales, etc.), rather than technical divisions. The advocates of the plan point out that such divisions would be more nearly in accord with types of work in industry and with the differing abilities and inclinations of students. Do you think there is merit in this idea? Is it worth a serious trial in one or more institutions?"

	Per cent
Yes, there is merit in idea	37.3
No, there is no merit in idea	31.0
It is worth a trial	39.8
It is not worth a trial	24.3
Unclassified	4.6
Unstated	15.9

A small number enthusiastically favors the suggestion. A large group distinctly oppose it because it is considered unwise to differentiate during the college course; a still larger group believes the student unable to select his function with assurance, therefore that such specialization is unwise or at least of doubtful wisdom; and a number fear distinctly detrimental results from the errors of selection by the student. A small group favors the method if a sound foundation is laid, particularly for graduate work.

SHOP COURSES, THEIR SCOPE AND PURPOSES

Question VII deals with shop courses, their scope and purposes. The first part and the responses follow.

"At present there seems to be considerable diversity of opinion as to the scope and purpose of shop courses. What, in your opinion, should be the primary purpose or purposes of such courses—training in manual operations and acquirement of skill therein, training in management and production methods, training in the economics and business aspects of shopwork, etc.?"

	Per cent
Manual operations and skill	16.8
Management and production methods	61.6
Economics and business aspects	5.8
Shopwork not part of engineering course	7.1
Unclassified	6.7
Unstated	2.0

A considerable group believes that the shop courses give the engineering student the practical touch which the engineer is thought to need; a small number is decidedly favorable to the coöperative system; a considerable group believes that the shopwork should be kept to a minimum or omitted entirely, and still another expressed the view that the acquisition of manual skill should not be the aim of shopwork, but rather that its purpose should be to fix in the mind the principles underlying the technical training.

VACATION SHOP EXPERIENCE VS. COLLEGE SHOP TRAINING

The second part of Question VII deals with the desirability of shop experience during the vacation period, as compared with training in the college shop. The responses to this portion of the question follow.

	Per cent
Vacation employment	36.8
College shop training	22.2
Either	0.84
Both	26.8

A considerable portion of the comment on this question favors shop training during vacation, because it is believed the practical work will attract the students' interest more than the work in college. A number favor both college and shopwork, because variety can be secured in the college with greater facility than in regular shop employment; and a few favor strictly college training because of the greater variety of work to be secured there.

RELATIONS THAT SHOULD OBTAIN BETWEEN THE NATIONAL ENGINEERING SOCIETIES AND THE EDUCATIONAL INSTITUTIONS

Question VIII is perhaps the most significant in the questionnaire, for it deals with the relation which should exist between the national engineering societies and the educational institutions. This relation is fundamental to the life of the profession and quite merits the unusually broad comment given it by those who answered the questionnaire.

The first part of the question and the responses follow.

> "A general expression of your views on this important question is desired and in particular it is hoped that you will contribute suggestions of concrete measures which may be taken to foster a closer relation and a more effective coöperation between the societies and the colleges."

	Per cent
Yes, more direct influence	63.6
No, societies should not	7.5
Present relation close enough	6.7
Unclassified	7.1
Unstated	15.1

The agreement is general that effective coöperation between the societies and the colleges should exist, and many suggestions are made for securing it. Few believe that the societies should dictate the courses, somewhat after the manner which obtains in the medical profession, but a large number agree that this is impracticable, partly because the engineering profession itself is far from a unit in its organization; partly because it is believed that teaching is in itself a scientific profession, based upon sound principles which are not commonly understood by those who are not teaching. The greater number of suggestions look to cordial coöperation between the societies and the faculties of the engineering schools. It is felt that the schools should look to the societies for a statement of the requirements of the profession and industry and that the societies should look to the schools for the carrying out of the training necessary to meet those requirements in accordance with the established principles of education.

It is suggested that for the guidance of the students, the societies should prepare sound, well-considered statements of the qualifications necessary for the engineers engaged in the major lines of industry. It is also wisely suggested that opportunity should be made for outstanding practitioners to meet with the students for informal discussions and to answer the multitude of questions students are always ready to ask if met on their own ground.

The second part of Question VIII and the responses to it are as follows:

> "Scientifically, and as one means of exercising a direct influence upon engineering education, do you believe that The American Society of Mechanical Engineers should maintain a list of approved institutions whose graduates would be accepted for Junior Membership and in which Student Chapters would be recognized?"

	Per cent
Yes	58.0
No	28.5
Unclassified	4.6
Unstated	8.9

The greater part of the comment is favorable to the action suggested, but there are a number of sound, negative remarks chiefly directed toward the possibility of the assumption of too much authority by the Society.

The third part of Question VIII seeks a basis for carrying out the second part. It and the responses follow.

> "If so, what would be the general principles or basis on which such lists should be prepared? Should the points following be considered?"

	Per cent
Length of course and graduation requirements	47.2
Qualifications of members of teaching staff	41.5
Admission requirements	32.6
Physical plant and financial resources	29.3
Proportion of curricula devoted to mechanical engineering	36.9
Unclassified	1.2
Unstated (for entire question)	38.2

Since there is such a distinct division of opinion upon the desirability of the preparation of such lists, it is not surprising to find in the comment much confusion regarding the method of making up such lists. But in general it may be said that the plan is not favored.

CONCLUSION

The invitation for general comment upon the questionnaire was widely accepted. Much comment was favorable to the questionnaire itself; much favored the closer coöperation between the societies and the colleges; but a very large portion was devoted to stressing the desirability of a broader foundation for the engineer, of broader cultural training in the four-year course, with provision for a high degree of specialization through graduate courses at selected institutions of high standing.

The comment and opinions are necessarily varied. They come from men engaged in all branches and phases of mechanical engineering, from the strictly technical work of design to the broad administrative work of the president of a large corporation. They reflect distinctly the character and experience of those making them. Sometimes they stress a course deemed responsible for success; at others they seek to correct a deficiency in training felt by their makers. They cannot be summed up mathematically, but the general import of the opinions expressed is that the training of the engineer should be particularly sound in whatever subjects are given; that more cultural and elementary scientific subjects should be included in the usual four-year course than it now contains, and that the more specialized technical work should be sacrificed to make room for them. Manifestly, it is appreciated that the graduate will rarely have available the incentive or the facilities for the further study of the natural sciences and that the foundation in them must be substantially entirely laid during his college course, whereas, if he is given a trained mind, these fundamental, cultural, and scientific subjects and the fundamental technological subjects, his direct professional interest will lead him to acquire the additional technical training during the earlier years of his practical work. It is understood that at best a four- or even a five-year course cannot make the student a finished engineer, but can only prepare him soundly for the study of his profession, and that a broad, substantial foundation upon which he may build any kind of a career is far better for him than the narrow specialized course which is too often unsuited to his personal qualifications or his opportunities. It is clearly shown by the questionnaire and by the comment thereon that large numbers of engineers are engaged in other major divisions of engineering than those for which they were specifically educated, and that still others, in large numbers, have passed through the technical phases of the professional work into administrative or executive positions where the broad training is of the utmost importance. It is clearly desirable that the specialist shall have opportunity, as a graduate student, to delve deeply into the work of his choice, but that the normal course shall turn out men at perhaps the most formative period of life, well equipped to take up any branch of engineering, any line of work opportunity provides or taste dictates, and to carry it out with satisfaction and success.

Electric Transmission for Internal-Combustion Engines

Principal Features of Mechanical, Pneumatic, Hydraulic, and Electric Transmissions—Application of Automatic Speed-Torque Control to Gas-Electric Motor Buses, Rail Motor Cars, and Switching Locomotives

By HERMANN LEMP,[1] ERIE, PA.

THE internal-combustion engine is the most efficient prime mover today, both as regards power furnished per pound of fuel and per pound of power plant; and the ease and efficiency with which power is obtainable from liquid fuel, even in small units, has led to its wide application on land, water, and in the air. It has made flying practical.

Conceding all this, a normally designed internal-combustion engine has nevertheless certain limitations which must be met to apply it to any particular service.

On open throttle it furnishes substantially constant torque and horsepower proportional to its speed. It is not easily reversible, particularly when not under load.

When running under governor at nearly constant speed it will furnish automatically variable torque up to the maximum obtainable under open throttle, but whenever that maximum is exceeded the engine will stall.

For marine and air navigation the conditions of service are such that normally the maximum torque is not exceeded. For air navigation the engine is never reversed. In both cases, varying the fuel admission is sufficient to control the speed of a vessel within wide limits when traveling in one direction.

For traction on land, however, harder conditions have to be met, and the variations in torque are so great that some variable-speed torque transmission must be interposed between the prime mover and the load. Otherwise the engine will either stall or race.

The Ideal Transmission for Land Traction

The ideal transmission for such a service is one that will permit the operator to vary the horsepower of the engine at will by varying the fuel supply only, while relying on the transmission itself to so proportion the relative factors of torque and speed that they will adjust themselves automatically to the service demand existing at any given time.

Such a transmission should be of light weight, low first cost, low maintenance, and should transmit the power with the least amount of loss, friction, etc., which usually manifests itself both in heat and wear.

The automatic adjustment of torque and speed should be continuous from one extreme to the other without intervening step-by-step motion. It should be inherently automatic, not depending upon relays controlling other circuits. Its maintenance should fit into existing general service knowledge. It should be elastic so as not to transmit shocks from road obstacles to the engine proper. It should permit an easy placing of more than one engine unit into service, when needed.

It is evident that these specifications cannot be met in toto by any particular transmission, and in accordance with conditions to be met a choice of the more important items will have to be made to suit each particular case. To a great extent size and weight of vehicle will offer a clue to choice.

Principal Means of Power Transmission

The leading means of transmission are:

Mechanical	Hydraulic
Pneumatic	Electric

Experience with rail motor cars and locomotives has thus far shown that mechanical transmission is now practical up to 27 tons; hydraulic up to 60 tons; electric up to 120 tons and over; while pneumatic remains untried as yet in large sizes.

As will be seen later, the weight limitations are not fixed but are subject to alterations and overlapping. For instance; improved materials and technic are gradually raising the weights of vehicles to which mechanical transmission can be applied; and, on the other hand, superior control and maintenance and lower manufacturing costs make it desirable to apply electric transmission to lower weights than heretofore thought permissible. As with all engineering propositions, careful studies from all viewpoints will ultimately develop a type which is fit to survive.

Hydraulic and pneumatic transmissions share with the electric a certain amount of flexibility and elasticity, allowing the prime mover to be placed on spring-supported platforms in any location suited best without regard to the location of the motor element transmitting the energy to the driving wheels.

Fig. 1 Erie 3/4-yd. Gas-Air Shovel, Side View

A Gas Shovel Employing Pneumatic Transmission

Regarding pneumatic transmission, the author desires to place on record a promising application to excavating machinery. The Erie Steam Shovel Company, which has built for years very successful steam-operated shovels of 3/4 cu. yd. capacity and smaller, has given the problem of replacing the steam engine by an internal-combustion engine serious thought for some time. A. C. Vicary, vice-president of the company, suggested a few years ago that the flexibility of control and simplicity of operation of the steam shovel, so thoroughly recognized, could be retained if, in lieu of steam, an internal-combustion engine were made to compress air for operating the swinging and crowding motions while driving the hoist, which absorbs approximately 60 per cent of the power, direct from the gas engine.

A steam shovel in its best form uses three independent motors for its principal function, the energy being divided about as follows: 60 per cent for hoisting; 20 per cent for swinging; 20 per cent for crowding. Of these three functions the two latter require delicate touch and quick response to the operator, and thus far a quickly moving fluid without inertia, like steam or compressed air, has best answered for this service.

It was therefore decided that for these two functions compressed air should be used, and since the three functions overlap each

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other in time during a complete cycle (lasting about 15 seconds for a ¾- to a 1-yd. bucket), that means should be provided to automatically unload the air compressor during such time when all the power is needed for hoisting. This fundamental principle was worked out by the late E. J. Armstrong, and embodied in a successful working shovel before he died last January. (See Figs. 1, 2, and 3.)

Ordinarily air transmission is inefficient because the heat generated during compression is usually lost by radiation when air is stored or carried a great distance. To minimize this loss, air compressors are sometimes built to compress isothermally, or usually adiabatically in several stages with intercooling between stages.

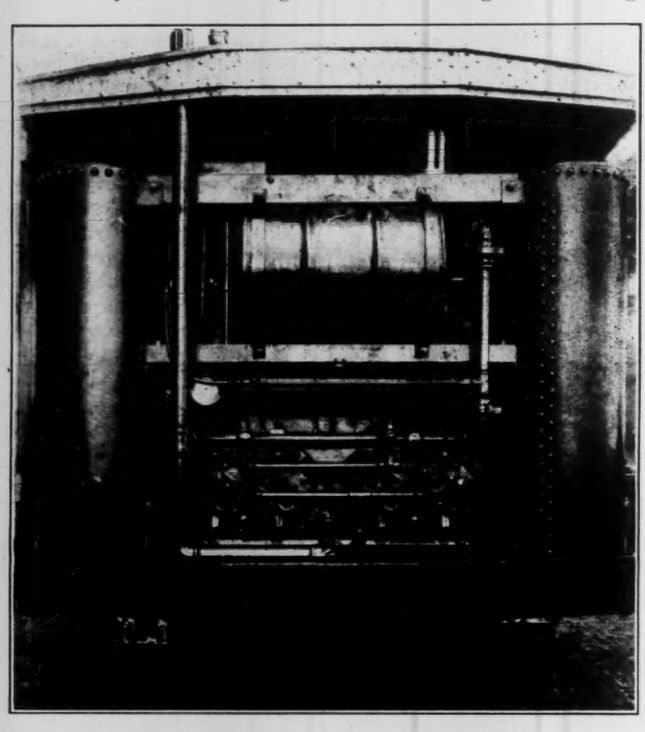

FIG. 2 ERIE ¾-YD. GAS-AIR SHOVEL, REAR VIEW

Again, air engines are inefficient owing to loss of heat during expansion.

In a self-contained unit requiring neither storage nor transportation of air to a distance, the loss of heat by radiation may be minimized, hence a single-stage compressor delivering its air hot and without appreciable time storage direct to the air engines, will materially increase the efficiency of the latter and be much simpler than a multi-stage compressor.

Again, the efficiency of the air engine will be increased if the air be preheated, and since the exhaust from the gas engine represents otherwise waste heat, it may be utilized for this purpose.

It should be noted that adding heat to compressed air before it is delivered to an air motor is one of the most efficient methods known for transforming heat into power.

The volume of compressed air at constant pressure being proportional to its absolute temperature, will be increased 1 per cent for every 5 deg. fahr. rise therein, and the cost of producing a cubic foot by adding heat is usually less than one-eighth that of producing it through compression. Tests which have been conducted with these shovels show that the overall efficiency, as expressed in gasoline consumption per yard excavated, is higher than that of any friction-operated shovel, that crowding and swinging are much more easily performed by an operator used to steam-shovel practice, and that the apparatus is maintained at less cost.

Incidentally, the air-compressor plant may be used for air drills or other tools requiring compressed air for operation.

HYDRAULIC TRANSMISSIONS

In hydraulic transmission the Waterbury Tool Company has done more in this country than any other concern. Where all the load has to be transmitted hydraulically the attendant heating, and cooling, the leakages, and the friction in the transmitting pipes have proved to be serious problems. As far as the author is aware, no more than two of these transmissions have been put into actual railroad service, and those using them are reluctant to express an opinion.

The Waterbury transmission acts smoothly and from extreme to extreme with little effort on the part of operator, and ought to be well adapted for slow-speed and heavy-pressure transmission not exceeding 150 hp.

In Europe the Lentz step-by-step hydraulic transmission is used up to about 200 hp., but has not proved satisfactory in larger sizes. A recent development of a differential hydraulic transmission invented by A. Schneider, of Winterthur, Switzerland, deserves close investigation. It is claimed that an efficiency of 87 per cent of normal transmission has been realized. (For full description see *Oil Engine Power*, October, 1925.) The chief advantage of this transmission lies in the fact that under normal conditions, when the differential part of the gear is ineffective and revolves as a locked body with the gears, direct engine transmission is obtained with maximum efficiency, while under partial revolving of the differential members the slip is converted into useful torque. In this it resembles the Entz & Owen magnetic-electric transmission used before the war in a number of pleasure automobiles.

The practical application of the Schneider transmission to Diesel locomotives will be watched with interest. It would seem to call for elaborate workmanship, and yet it represents a rigid transmission between engine and driving wheels, and lacks in this respect the elastic transmission of the Owen magnetic.

In the spring of 1924 the author read a paper before the Erie Section of the A.I.E.E. on internal-combustion-electric locomotives

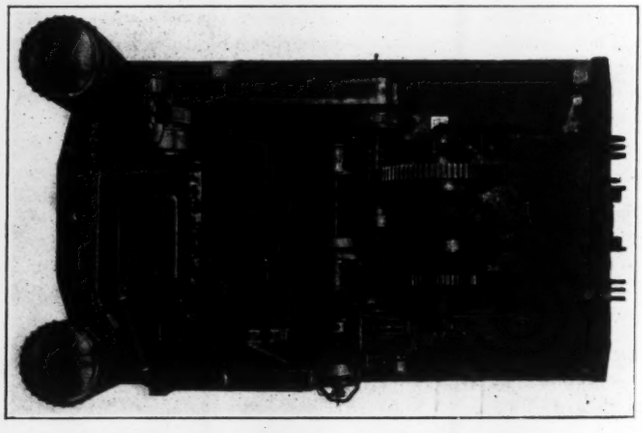

FIG. 3 ERIE ¾-YD. GAS-AIR SHOVEL, PLAN VIEW

which was published in a condensed form in the *General Electric Review* of October, 1924. As much of the material contained therein is of interest now and was at that time not widely discussed, it is thought to be perfectly proper to quote here its essential portions, especially so since its presentation one particular method of automatic speed-torque control has found practical application in three widely different fields.

From now on the author will confine himself to the electric transmission since it offers at once a workable solution for large units when its efficiency becomes so high that the losses are negligible and the only debatable question is whether it is worth the additonal weight and first cost.

ELECTRIC TRANSMISSION AND ITS ADVANTAGES

The chief advantages of electric transmission may be summarized as follows:

1 Lower cost of maintenance
2 Greater reliability
3 Superior control.

Maintenance. The cost of maintenance is less because the power plant is less subject to shocks. Between the driving wheels and the engine there are at least two magnetic air gaps through which all energy has to be transmitted and by means of which

reactionary stresses are cushioned. All parts of the engine and accessories are easily accessible due to the possibility of placing the apparatus in any position desired. Reliable and accessible oil, water, and air connection can be made.

Electric equipment has demonstrated its low cost of maintenance, and the series railway motor is generally acknowledged to be the most sturdy apparatus in railway service.

Reliability. Electric equipment possesses greater reliability be cause:

Speed changes are made without clashing.

The engine being mounted on felt on the spring-supported frame, is not subjected to hammer blows when passing over crossings, frogs, and switches. It is protected against dust and flying material.

Minor defects are easily detected and adjusted before they become serious due to the accessibility of engine.

Control. The control is superior to clutches and change gears for the following reasons:

Electric drive is equivalent to an infinite number of speed relations between the engine and car wheels, without any changes of clutches and gears.

The full engine output is available at all car speeds.

It permits driving through two or more axles, which is a considerable advantage on grades or slippery rails.

The rigid wheelbase of the driving truck may be short, permitting the use of shorter curves or Y's and turnouts.

Starting and acceleration are accomplished with absolute smoothness.

Conditions such as hauling additional trailers or negotiating heavy grades can be met which might be impossible if the maximum tractive effort of the locomotive or car were rigidly fixed by the gear ratio.

In case of failure of the brakes, the motors may be used to stop the car.

The engine can be loaded full at all speeds, thus tending toward fuel economy. High car speed may be obtained with low engine speed under certain conditions, and low car speed with high engine speed can also be obtained when desired.

The electric motor furnishes a continuous rotary effort which to duplicate would require approximately seventy-two cylinders. Its immediate effect is, other conditions being equal, to increase, the load which may be hauled without slipping. With steam locomotives the pounding on the rails by the vertical component of the connecting rods is about double that of the static weight of the locomotive. Hence heavier electric locomotives may be used on the same rails than steam.

Ultimately, electric locomotives will be the rule in largely populated centers. The service departments of such roads will be ready to receive internal-combustion-engine locomotives with electric motors, and the latter may, when entering an electric zone, be almost instantly converted to travel over the electrified zone with their own motors.

The larger the equipment the more economical becomes the electric transmission (Lomonossoff has shown an overall electric efficiency as high as 92 per cent), and the harder it becomes to transmit mechanically when gear shifts and clutches are used.

When electric transmission is adopted the prime-mover generator unit becomes at once a traveling power plant susceptible of being used for other needed functions. Electric power may be furnished to motors on trailers (snow plows, gun mounts, etc.).

Multiple-unit trains and double-end control are more easily installed than with other transmissions.

THE ELECTRIC DRIVE

The electric drive may be briefly described as follows:

A prime mover and direct-connected generator supply current through a controller to the motors on the truck without any intervening resistances.

Electric transmission is so easily controlled either by hand or automatically that one may make the broad statement that all electric controls are good, but some of them are better.

The methods of control may be properly divided into two fundamental types:

1 That in which the prime mover is operated at nearly constant speed under the control of a speed governor, and the electrical energy delivered to the motors is modified by field excitation of the generator.

2 That in which the speed of the prime mover is varied within wide limits, and the excitation of the generator field is controlled separately.

Constant-Engine-Speed Operation. When constant engine speed is employed, as is usual in stationary power plants and marine propulsion, the efficiency of the generator is at its maximum at full output, full speed, and falls off toward light loads. Where the service demands constant load, such as for main-line locomotives traveling a long distance under steady pull, this method may prove the most economical and cause the least complication, particularly if the internal-combustion motor is of the Diesel air-injection type using heavy oil as fuel. For this service a modified Ward Leonard method of control is ordinarily employed. The original Ward-Leonard control comprises a generator whose field is separately excited through a variable resistance and whose polarity is also changed by reversing the direction of the exciting current, in connection with a motor directly connected to the generator without any intervening resistances, but having a fully saturated field excited from the same exciting source as the generator. The motor is therefore accelerated, decelerated, stopped, reversed, and accelerated in the opposite direction by changing the polarity and volume of the exciting current in the main-generator field.

For traction work this Ward Leonard control has been modified: First, by exciting the generator always in the same direction, only varying its strength; and second, by using a series motor and reversing its rotation by reversing the flow of current through its armature. The generator speed being constant, the torque varies with the load and the excitation of the generator field.

The modified or unadulterated Ward Leonard control may also be supplemented with a differential series field on the main generator so proportioned to the maximum shunt excitation that under normal engine speed (throttle wide open by governor) full load, normal e.m.f. and current are furnished to traction motors.

The speed of the engine being maintained nearly constant by the governor, a variable hand-operated resistance in series with the shunt excitation of the main generator will permit lowering the speed of traction motors at will, while the differential series field will automatically reduce the motor speed if increased tractive effort is imposed by load.

Variable Engine-Speed Operation. The control of engine speed by means of either a throttled carburetor or a variable-capacity fuel pump is the method commonly used in automobiles or motor boats, and was adopted by the General Electric Company at the start in connection with gas-electric automobiles, buses, rail motor cars, and locomotives.

This fundamental method of control may be subdivided into a number of modifications as follows:

The engine is operated at variable speed by:

a A speed governor whose range of action may be varied
b A speed governor whose speed relative to that of the engine may be varied
c By hand adjusting the throttle or fuel supply to the engine
d By providing the engine with an overspeed or underspeed governor or both, and adjusting the speed between the two governor settings by hand.

With any adjustable governor speed the excitation of the generator field can be hand-controlled to keep the engine loaded to its full torque (which is equivalent to an open throttle). Carrying the excitation farther would stall the engine. This method gives probably the best average fuel efficiency and the longest life of the engine, but is open to the criticism that a skilled operator is required.

By locating on either side of the normal position of the swinging arm of a speed governor, valves admitting air alternately to either end of a cylinder, a piston traveling therein may be made to progressively increase the torque of an engine by opening its throttle. With the throttle remaining wide open a further movement of this piston will gradually unload the generator by introducing resistance in the generator field, thereby automatically producing a load suitable for the engine at any governor-speed setting determined by the operator. The same result may be obtained by

moving the piston electrically by means of contacts and electric-motor control.

A third method is the one first used on the switching locomotive at the Erie Works of the General Electric Company. In this locomotive, the prime mover drives, through flexible couplings on the same shaft, a generator and exciter. The field of the exciter is energized from a storage battery, and the exciter armature in turn excites the field of the main generator. The current from the main generator passes through a commutating field and a differential series field, and thence through the motors constituting the load. This method of control is shown diagrammatically in Fig. 4. Assuming the engine to run at any particular speed, the field excitation of the generator will be modified by the current flowing through the load to suit its own needs, drawing substantially constant energy within wide limits.

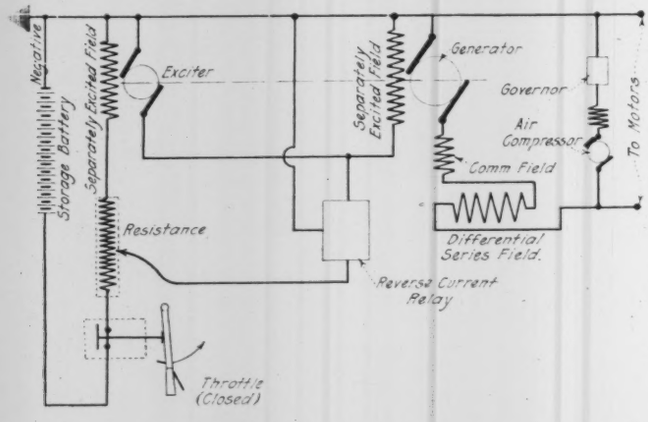

FIG. 4 DIAGRAM OF AUTOMATIC ELECTRICAL CONTROL FOR GAS- AND OIL-ELECTRIC LOCOMOTIVES

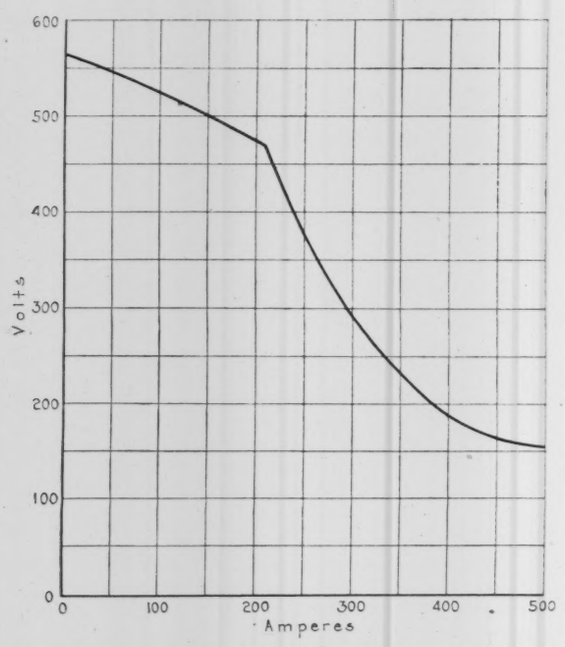

FIG. 5 VOLT-AMPERE CURVE OF GAS-ELECTRIC LOCOMOTIVE NO. 6206

The operator in moving the throttle lever from the idling position toward the full-speed position first excites the exciter field from the storage battery, then increases the speed of the engine, and thereby determines at any particular point the amount of power he wishes to use. The form, however, in which that energy is taken by the motor is determined by the load itself.

The resulting volt-ampere curve furnished by the generator at any particular speed is shown in Fig. 5.

This method of control is eminently suited for a switching locomotive where variable load is the rule of service. In its practical application the control has been made to approach that of a steam locomotive as nearly as possible, the throttle representing that of a steam engine and the controller handle the reversing bar, the air brake being the same in both. Hence it has been invariably the company's experience that any steam engineer would take to the operation of the locomotive with the greatest ease.

APPLICATION OF AUTOMATIC SPEED-TORQUE CONTROL TO MOTOR BUSES

One of the applications of the automatic speed-torque control which has proved immediately practical has been to double- and single-deck, buses for city and interurban work. The Philadelphia Rapid Transit Company in the summer of 1923 undertook to supplement its trolley service with mechanically driven buses for the purpose of (1) supplying section of the city recently built up, but without trolley service, with transportation; (2) to prove a cross-town service between outlying communities not readily accessible to each other; and (3) to provide an additional choice of service on heavy arterial routes. (For more detailed information, see article in *Electric Railway Journal*, August 8, 1925.)

The first buses for this service were equipped with mechanical drive employing the usual shifting gears and clutches. J. A. Queeney, vice-president of the Philadelphia Rural Transit Company, was greatly interested in replacing the mechanical transmission by

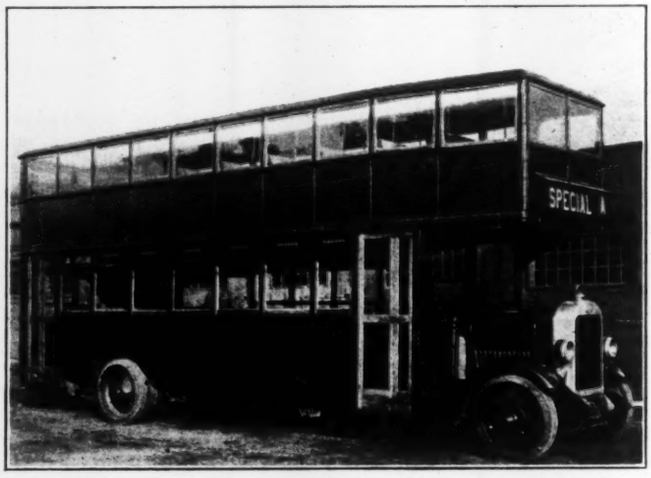

FIG. 6 64-PASSENGER BUS EQUIPPED WITH GASOLINE-ELECTRIC DRIVE. PHILADELPHIA RURAL TRANSIT CO.

an electric one, and to give the latter a thorough tryout a standard chassis, provided with mechanical drive, was rebuilt by the J. G. Brill Company, the General Electric Company furnishing the electric equipment, and motor bus No. 102 with electric drive was run in Philadelphia for the first time on June 13 ,1924. (See Fig. 6.) For particulars of this development and the historical background, reference should be made to the very complete paper read by Henry S. Baldwin at a meeting of the S.A.E., July, 1925. Mr. Baldwin has done some splendid work in connection with gas-electric transmission for buses and other vehicles for many years past, and has never lost enthusiasm, so thoroughly shared by the author, of the ultimate successful outcome of this mode of transportation.

The mechanically operated and gas-electric buses were then put through a parallel test by the Philadelphia Rural Transit Company engineers, and the outcome was so satisfactory that two hundred and twenty of these buses were ordered, most of which have been delivered and are in operation.

SAVINGS RESULTING FROM EMPLOYMENT OF ELECTRIC DRIVE

The usual objection raised against electric drive is that it is too expensive and adds to the weight of the equipment. Mr. Baldwin properly points out that in the final analysis it is not the first cost that counts, but ability to pay interest on the total investment. If it can be shown that an electric-driven motor bus can cover a greater distance in a shorter time and with more comfort to passengers, making it a more desirable means of transportation, it is plain that the motor bus with this form of transmission will cover more miles per day per dollar invested.

To substantiate this view, Mr. Queeney has given the author the following information. The first cost of a 64-passenger double-deck bus with gas-electric drive, double motor drive, is $12,500, while that of the mechanically driven bus of equal performance is but $10,500, showing an extra cost of $2000 against the electric drive, or $1500 when a single motor is used. A gas-electric bus will weigh approximately 16,000 lb. as against 14,000 lb. for the mechanically driven bus.

Commenting on statistics obtained from other cities, it appears that the average number of miles covered per hour with the gas-electric bus in Philadelphia, with its narrow streets, is 11.8 as contrasted with only 8.07 in New York City on Fifth Avenue and Riverside Drive.

The combined salaries paid to driver and conductor of $1.58 per hour, give on 50,000 miles run per annum per bus, a salary expense of $9800 for New York and $6700 for Philadelphia, showing a saving in one year of $3100 in favor of electric transmission.

RELATIVE FUEL ECONOMIES OF GAS-ELECTRIC AND GAS DIRECT-DRIVEN BUSES

It has further been found that the miles traveled per gallon of gasoline for the gas-electric and the gas direct-driven bus are practically a stand-off, or, if anything, in favor of the electric. Roughly they are 4 miles to the gallon. This refers to Philadelphia double-deck buses in city service. On the contrary, the lubricating-oil consumption is nearly twice the amount for the direct-driven bus as against the gas-electric bus. An average of the requirements of six gas-electric buses shows that 46 miles are traveled on a quart of lubricating oil, whereas only $28\frac{1}{2}$ miles are run on the same amount with the direct-driven bus, both buses using identical power plants. This item alone will mean an annual saving of about $60 in favor of the gas-electric bus.

The explanation for the increased oil consumption seems to be that the engine when the gears are shifted mechanically reaches a maximum of 2700 r.p.m. while with the electric-driven bus the maximum never exceeds 1600 r.p.m. Furthermore, the actual total number of revolutions made in a given time is 20 per cent less for the electric drive.

The new buses have not been in operation long enough to give full results for maintenance expenses, but this much has been ascertained: that while the engine equipment of the mechanically driven buses requires inspection and overhauling every 2000 miles, the same engine after 4000 miles has not shown the need for overhauling. In this connection Mr. Queeney points out as an advantage of the electric equipment the fact that the inspection is greatly helped since the entire power plant of the gas-electric bus can be checked up readily by connecting it to a test panel provided with instruments and resistance box, so that any falling off in power from the normal is quickly detected and may be remedied.

The foregoing refers to the engine equipment only. The maintenance of clutches, differentials, and transmission gears is far in excess of the equivalent transmission, particularly when a properly constituted service department attends to both.

As the author sees it, the all-important feature in connection with this bus development is that the ease of operation relieves much mental and physical strain incident to the ordinary gear-shift operation. A bus with mechanical drive running approximately 180 miles per day on a ten-stop schedule with three shifts per start, would require 5400 gear shifts, while an electric-drive gear requires no gear shifts whatever and the 1800 starting impulses are smooth and without jolt or strain on the driving mechanism.

Through the courtesy of N. T. Brown, superintendent in charge of the Cumberland Garage of the Philadelphia Rural Transit Company at Cumberland & 15th Sts., which has a capacity of 175 buses, the author had the pleasure of interviewing one of the oldest drivers in their employ, who used to operate the mechanically driven buses. He stated that after eight hours' work he was physically and mentally tired out, and any additional work required was viewed with a great deal of reluctance. Now the driving is so simplified and both the mental and physical strain so relieved that frequently drivers request the management for additional trips.

The responsibility of a driver in congested traffic, watching for passengers, automobiles, and observing traffic rules, particularly when moving 26,000 lb. on a slippery pavement, demands that the manipulation of the bus as a whole should be made as simple as possible. Any one operating a pleasure car may enjoy the special skill required for deftly changing gears in congested traffic, but when it becomes a "bread and butter" proposition, coupled with responsibility for doing the work day in and day out, the value of a simplified control that does away with changing gears and moving clutches cannot be overestimated. It will add to the life of the operator as well as to that of the mechanism he operates.

Mr. Brown brought out the interesting fact that since this automatic control has been introduced drivers and conductors need not be two different persons, and as a matter of fact, each conductor is qualified to act as a driver and vice versa, simplifying the handling of the crews in this organization.

Referring once more to the gasoline consumption, the author anticipated from the results reported by Mr. Baldwin that since the engine speed in a gas-electric bus is about twenty per cent lower than the average engine speed of the direct-driven car, the gasoline consumption should be less—at any rate, not any more than that of the direct-driven bus. He looked for this result because acceleration and deceleration in crowded city traffic requires an especially skilful operator to keep the gasoline consumption down. Hence as the manipulation is made automatic, it is susceptible of giving economic results with an average operator equal to those of a skilled operator on a mechanically driven bus. But the author was astonished to learn that single-deck buses carrying thirty-three passengers, provided with gas-electric drive and traveling between Philadelphia and Atlantic City and between Philadelphia and New York, showed a gasoline consumption of from 13 to 14 miles to the gallon, while under similar service mechanically driven buses would run 10 miles to the gallon. After having verified these figures it took him some time to determine the probable reason for such a performance.

The explanation, as he sees it, is that with gas-electric drive with series motors the vehicle is naturally self-coasting; in other words, when the throttle is closed by the driver, the motors will run ahead of the generator and not drive backward through the engine as would be the case in a mechanically driven bus. Such a condition of course might be paralleled with a mechanically driven vehicle if the driver were to release his clutch every time he removes his foot from the accelerator, but no driver does this regularly. It may be done on long hills. Many of the much-advertised mileages of passenger cars are obtained in some such fashion by skilful drivers, but the fact remains that no one does this in regular service. With the gas-electric transmission, however, it takes place continuously.

Any one who rode a bicycle before the advent of the coaster brake and then added the latter to his equipment, will understand what the author means when he says that with a coaster brake bicycle riding takes less exertion.

The satisfactory performance of the electric transmission on the buses, coupled with automatic control, will undoubtedly bring about its application to other commercial vehicles such as taxicabs and auto trucks.

Similar results are being obtained abroad. The author understands that the London Omnibus Company has shown a saving of from ten to fifteen per cent in operating expenses in connection with the Tillings-Stevens electrically driven bus as compared with the standard mechanically driven vehicles.

APPLICATION OF AUTOMATIC SPEED-TORQUE CONTROL TO RAIL MOTOR CARS

The automatic speed-torque control has also been successfully applied to rail motor cars.

The 88 gas-electric cars built by the General Electric Company and placed in service as early as 1909 are for the most part still in satisfactory operation, chiefly on western railroads, and it was due to the service record they established that railroads have seriously taken up again the use of self-propelled rail cars on their branch lines as feeders to the main arteries of travel. Much credit for these results is due to the foresight and engineering ability of Messrs. W. B. Potter, Henri Chatain, E. VerPlank, and their associates.

Attention is drawn to the report of A.E.R.A. through their

committee on Heavy Traction (see *The Railway Age*, October 17, 1925), in which the cost of operation from July 1, 1922, to June 30, 1924, of nine General Electric motor cars built in 1911 on the St. Louis-Francisco Railway Co. showed a saving of nearly fifty cents per train-mile over steam trains operated on its branch lines. This saving would indicate that these cars paid for themselves completely in two years. They are still in good operating condition after fourteen years of service, and even now the maintenance per annum of car bodies, trucks, engines, transmissions, and all accessories is less than ten per cent of the first cost of the cars.

Simultaneously with the development of the General Electric gas-electric car, the Union Pacific, at Omaha, placed into service

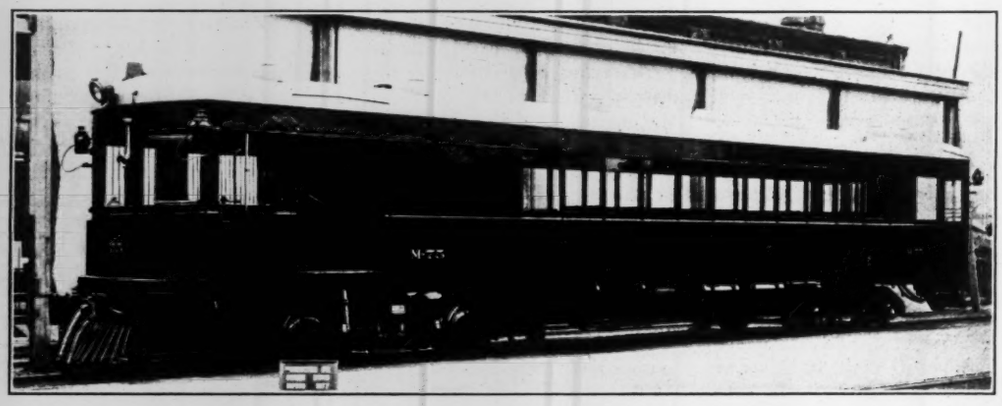

FIG. 7 J. G. BRILL MODEL 75 MOTOR CAR EQUIPPED WITH MECHANICAL DRIVE

a large number of McKeen motor cars with mechanical drive. It is rather significant that of these two pioneers the electrically driven car has demonstrated a better serviceability through lower maintenance costs and greater reliability of operation.

H. L. Hamilton, president of the Electro-Motive Company of Cleveland, a practical railroad man and one thoroughly conversant with the motor truck, made a special study to satisfy himself as to the relative merits of mechanical and electrical transmissions for railroad purposes, and became convinced that, based upon the records of the two pioneer cars, the future lay with the electric transmission.

Progress in the art of building gasoline engines and the general advance in automotive engineering has made it possible to produce a lighter gas-electric car than in the past, and the advent of the automatic speed-torque control has removed from the electric control previously used one of the objections then open to criticism.

At the same time practical car builders, like the J. G. Brill Company, of Philadelphia, felt that if a mechanical transmission were built by taking advantage of the best engineering experience from automotive and railroad standpoints, a rail car could be produced with less weight and less cost while giving reliable performance, such as is demanded by railroad service.

At this point, the author desires to draw attention to an able paper presented by C. O. Guernsey, chief engineer of the Automotive Car Division of the J. G. Brill Company, at the semi-annual meeting of the S.A.E. in July, 1925. This paper deals thoroughly with probably the most powerful rail car produced with mechanical drive, and the author had occasion recently to inspect the general workmanship of this car. It ought to be infinitely better suited for practical railroad service than the old McKeen cars. (See Figs. 7 and 8.)

From complete data courteously furnished by the J. G. Brill Company and the Electro-Motive Company, it appears that Mr. Guernsey is substantially correct when he says that the weight and first cost of a rail car with electric transmission is about one-third more than that of a car of equal carrying capacity with mechanical drive. But practical results recorded with both seem to indicate that while under certain service conditions (flat country), performance of the mechanical transmission is satisfactory, a different result is obtained when the car is operating trailers on grades. Under those conditions the average transmission efficiency of the electric is higher than that of the mechanical because with automatic speed-torque control the demands of the service can be met automatically without any exertion on the part of the operator, and the most economical and suitable gear ratio is available.

Any one used to driving an automobile with sliding-gear transmission will notice that while it takes no great effort to shift gears on the level, it is a different proposition altogether to shift them on an up-grade. Even good operators occasionally get caught in a jam and stall traffic because the car tends to slide backward during the short period necessary for shifting gears, and the loss in inertia of the car may be sufficient to fall below the torque required for the next higher gear. In other words, the power of the engine has to be greatly in excess of the actual requirements to permit an easy shifting on an ascending grade, and in actual experience with rail cars it has been found that many drivers will have to stay in the lower because they cannot transfer to a higher speed.

To clearly illustrate this: The Electro-Motive Company has prepared a chart (Fig. 9) on which the speeds, tractive efforts, and the rail horsepowers of two motor cars are compared, both having the same engine equipment and same weight but one being provided with mechanical transmission and the other with electrical transmission. It will be seen from the figure that the tractive effort in the case of the electric is relatively smooth and even as contrasted with the curve for the mechanical transmission, which resembles steps on a stairway. Similarly the horsepowers delivered to the wheels of the cars when compared show a smooth curve for the electric as contrasted with the oscillatory curve for the mechanical transmission.

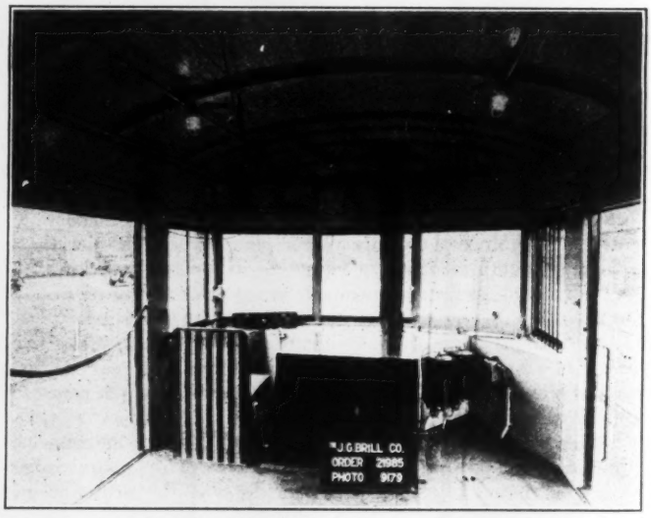

FIG. 8 OPERATOR'S COST OF MOTOR CAR SHOWN IN FIG. 7

In this connection Mr. Hamilton writes as follows:

> Next to economy of operation, the matter of continuity or regularity of service is of vital interest to steam railroads. In this connection the ruggedness of the electric transmission and the remote possibility of damage to it when in the hands of inexperienced and unskilled operators are of utmost importance. Where railroads are using quite a number of motor cars scattered over the system, it is not always possible to have a man available who is thoroughly qualified and skilled in the operation of the motor car. Quite often the operator is a locomotive engineer that is well along in years and more or less inexperienced in the handling of an automobile, and at best has done but little driving and only with a light touring car.
>
> In an emergency, which quite often occurs, it is necessary to put any engineer available on the motor car, and with the electric drive it is almost impossible for him to get into any trouble or do any damage to the equipment regardless of his inexperience, on account of the electrical equipment being so designed that no amount of carelessness in handling can cause any trouble.
>
> This condition does not obtain with the mechanical drive because, owing

to the enormous weights and inertia forces, considerable skill is required to successfully change gears even under favorable circumstances, and the possibility of the operator's selecting the wrong gear when changing or allowing his foot to slip off the clutch at the wrong time quite often damages the transmission at the moment, or at least strains it so that in a few days it does give trouble.

This serious factor makes it very dangerous for other than a skilled operator to attempt the handling of a mechanical-drive car and it should be added that troubles developing from this condition are responsible for considerable time out of service on the part of the mechanical cars.

We have several instances where the motor cars are pooled in passenger service on their respective divisions, which means that locomotive enginemen arriving in a terminal on a steam train, get right on a motor car and go back over the division. This means that in some cases ten to twelve enginemen handle the motor car in rotation. Operating officials admit that this could not be done with mechanically driven cars, as it has been often attempted with disappointing results.

FIG. 10 TYPE S. E. GAS-ELECTRIC MOTOR CAR MADE BY THE ELECTRO-MOTIVE CO., CLEVELAND

From data obtained from the Electro-Motive Company, cars now in daily operation pulling standard coaches will give approximately 150 ton-miles per gallon of gasoline, which compares favorably with the statement of Mr. Guernsey in which he claims a gasoline consumption of 120 ton-miles per gallon for the mechanically driven car.

This better showing of the electric transmission versus the mechanical transmission would indicate, as with the buses, free coasting on level, higher average all-around efficiency available at all times, and the possibility of using the gasoline engine more nearly at its most economical load and speed whether the car speed be high or low; all these three combined explain the higher fuel economy in gasoline cars with electric drive.

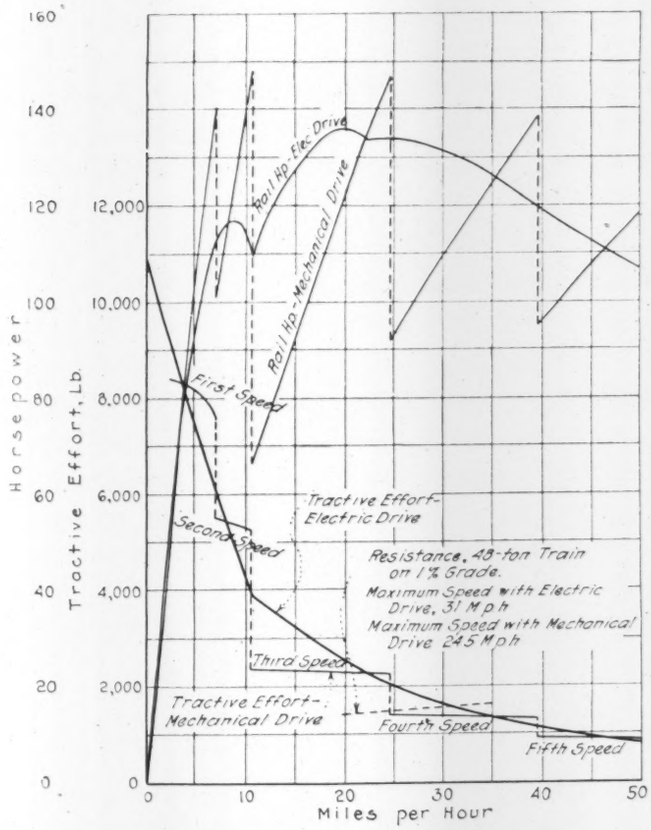

FIG. 9 COMPARISON OF SPEED-TRACTIVE EFFORT AND SPEED-HORSEPOWER CURVES OF TWO MOTOR CARS

No. 1—An existing motor car with mechanical transmission.
No. 2—The same car with electric transmission.

	No. 1	No. 2
Average tractive force, lb	2730	3000
Average horsepower	107	118

The Electro-Motive Company has placed into service about 30 cars which are nearly all hauling standard railway coaches weighing from 27 to 42 tons as trailers. These cars are available for service approximately 97 per cent of the time, a record unequaled by any other automotive power of any steam railroad today unless it may be electric locomotives in the electrified areas. (See Figs. 10 and 11.)

To illustrate that the gas-electric car is better fitted than the mechanical for branch-line service with trailer in hilly country, the following communication from William J. Cantley, mechanical engineer of the Lehigh Valley Railroad Company, is quoted:

> After a careful comparative test had been made between Brill 75 mechanically driven car, and No. 108 gas-electric demonstration car of the Electro-Motive Company, an order was placed for five of the latter.
>
> For the particular service existing on the Lehigh system the gas-electric is better fitted to do all of the various duties expected to be done on branch lines, and which are now performed by steam locomotives, namely, hauling heavy standard coaches on up grades and occasionally switching freight cars in yards, in addition to the running of regular service between points on the branch to the junction of main line.
>
> The ability to progressively change tractive effort with speed without fear of stalling or racing engines is considered worth the difference in price. It is admitted, however, that in level country and in connection with special light trailers, the 75 Brill is considered satisfactory on account of lower weight and first cost.
>
> In view of the limited experience to date, the maintenance and gasoline consumption with trailers is thought to be about equal.

Attention is herewith drawn to an interesting article by J. Wanamaker, electrical engineer of the Chicago, Rock Island & Pacific Railroad, appearing in *The Railway Age* of September 19, 1925 in which he describes the conversion of three Rock Island McKeen cars to gas-electric drive.

Mr. Wanamaker's article emphasizes the intelligent supervision given by the engineering department to properly educate and train their operating department in the use and maintenance of their equipment. He says:

> By employing electric transmission of power to the driving wheels, a quick and smoother acceleration is obtained with comparative high starting effort. The transmission is flexible and self-adjusting for all different road conditions, leaving little need for the exercise of expert judgment and skill in the manipulation of the throttle and control handle. Consequently the average engineman is perfectly at home after operating the car for a short time.

The General Electric Company's experience has been similar in that with their early motor cars it took never less than two weeks to properly instruct a steam engineer in the handling of a motor car before it could be left in his hands. With the automatic control, a few hours are sufficient.

The Union Pacific Railroad Company has also converted successfully one of its McKeen cars, using a Sterling gasoline engine and General Electric Company electric equipment.

The author fully agrees with Mr. Guernsey in his statement that there is no need of increasing the size and power of self-propelled motor cars beyond that required for pulling one trailer, as frequent service is the only weapon the railroads now possess to revitalize their branch lines against the competition of the motor bus and interurban electric cars.

When railroads require bigger power on branch lines where gas-electric motor cars are now used and desire to unify both supply and maintenance departments necessarily different from those for

FIG. 11 OPERATOR'S STATION IN MOTOR CAR SHOWN IN FIG. 10

steam locomotives, internal-combustion-engine electric locomotives should be used.

That the J. G. Brill Company is fully aware of the advantages of electric transmission of the automatic speed-torque-control type is proven by their building high-powered gas-electric cars of their own. In building both the mechanical- and the electric-transmission cars the company has chosen a wise course, in that it will enable it to concentrate on the one best suited for any particular condition. (See Fig. 12.)

In making a comparison particularly between the Brill 75 and the gas-electric of the Electro-Motive and the J. G. Brill Company's gas-electric cars, the author has no intention of slighting the many successful mechanically driven rail cars produced by the Sykes Company, the Edwards Railway Motor Car Company, the O'Neida Manufacturing Company, and others, nor of overlooking the application of remote electropneumatic control for operating individual multiple units of well-tried traction motors as embodied in the Mack car (see *The Railway Age*, September, 1926).

Distant pneumatic control has been successfully applied to individual clutches and gear sets in Germany in connection with rail cars weighing 12 tons, and that German engineers have hopes to carry such a transmission, but operated by an electromagnetic clutch instead, to locomotives using 1200 hp., is vouched for by Professor Lomonossoff.

The Canadian National Railways have recently developed and placed into service two types of Diesel-electric motor cars which have many interesting novel features. (For full description see *The Railway Age*, October 17, 1925.)

Both types use four-cycle, solid-fuel-injection Beardmore Diesel oil engines (of very light weight) of four and eight cylinders, respectively.

The four-cylinder engine (185 b.hp. at 700 r.p.m.) is used in a 60-ft. car (capable of trailing standard coaches at reduced speed), has General Electric electric equipment with variable-speed engine and automatic speed-torque control. (Seven of these are on order.)

The eight-cylinder engine (340 hp. at 650 r.p.m.) is used in an articulated car seating 126 passengers. This type has Westinghouse electric equipment, modified Ward Leonard control with drooping characteristics, and charges a storage battery of sufficient capacity to haul the train at one-half car speed if the engine plant should come to grief. (Two of these units are on order.)

Both of these cars represent a distinct progress in rail cars and light-oil-engine design.

Before leaving the subject of gas-electric cars on rails it will be interesting to compare the General Electric gas-electric car of 1909 with the Electro-Motive gas-electric car of 1924 and the Brill-Westinghouse of 1925, as follows:

Type of Car	Length Over All, ft-in.	No. of Passengers Seated	Total Weight, tons	Engine
General Electric R.E.-57–B-6—1909	59	54–76	40.5	200 b.hp.
Electro-Motive Type S.E.—1924	59–7	54	35	175 b.hp.
Brill-Westinghouse—1925	60	50	44	250 b.hp.

AUTOMATIC SPEED-TORQUE CONTROL GAS- AND OIL-ELECTRIC SWITCHING LOCOMOTIVES

The third line in which automatic speed-torque control has succeeded in establishing its usefulness is in connection with gas- and oil-electric switching locomotives.

June, 1924, a few weeks following the first description of both the 40-ton General Electric gas-electric locomotive provided with a Sterling 180-hp. gasoline engine (see Fig. 13), and the 50-ton General Electric locomotive fitted with a 300-hp. Ingersoll-Rand oil engine, saw both of them in New York City demonstrating, the first in the yards of the Pennsylvania Railroad Company, and the second on the West Side for the New York Central Railroad Company. Both proved conclusively that reliability of service

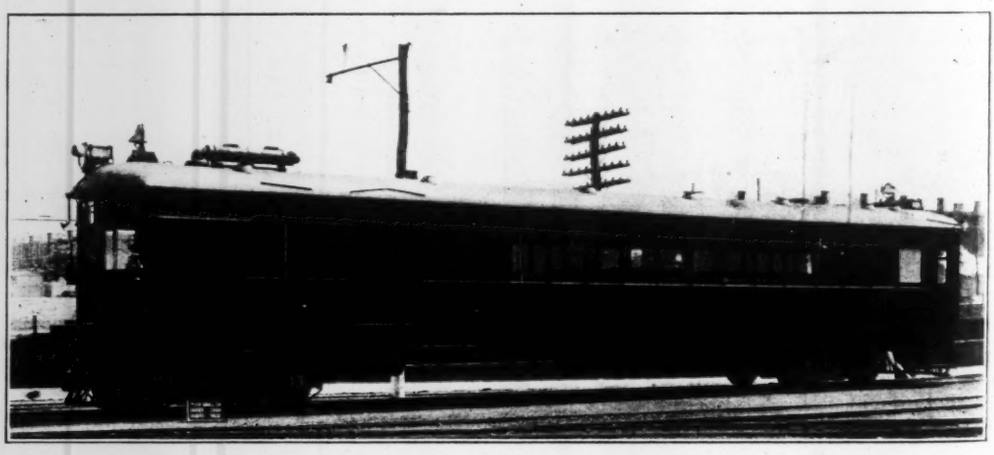

FIG. 12 BRILL-WESTINGHOUSE MODEL 250 GAS-ELECTRIC MOTOR CAR

(in case of the oil-electric, 24-hour service with changing crews) could be furnished with a fuel cost very much lower than for steam locomotives. (See Fig. 14.)

Similar demonstrations were given the New Haven, Long Island, Baltimore & Ohio, Reading, and the Boston & Maine railroads.

The original oil-electric locomotive, which now is in daily switching operation in the yards of the Ingersoll-Rand plant at Phillipsburg, N. J., served as a basis for the design of a modern 60-ton switching locomotive by the General Electric, the American Locomotive, and the Ingersoll-Rand companies combined, and this first

regularly designed locomotive has been acquired by the New Jersey Central, and is in operation at Bronx terminal, New York. (See Figs. 15 and 16.)

In the meanwhile, a 100-ton, two unit (total 600 hp.) locomotive after undergoing a series of trials at Erie will be seen in operation on the Long Island Railroad. In this unit two interesting features are being demonstrated, first, the ease with which generators with drooping characteristics will deliver their load without interference to a common bus bar; and second, the additional operative reliability vouchsafed by two independent units.

During all these demonstrations one fact loomed largely; namely, that, as with the bus and rail cars, the operation is so simple that any steam-locomotive engineer could step in and after a few moments' teaching, operate one without a hitch.

The tractive-effort curve of the 60-ton oil-electric locomotive shows the wide range of operation possible with only 300 hp. of prime mover. (See Fig. 17.)

Another interesting oil-electric locomotive has been completed and is undergoing demonstration trials in various yards. It is a 1000-hp. Baldwin-Knudsen Diesel locomotive with Westinghouse electric equipment. (For full description see *Oil Engine Power*, September, 1925.) This is the largest oil-electric locomotive yet built in this country, and from it some interesting comparative data will soon be available.

Two features stand out prominently: First, the gearing up of the generator from 450 r.p.m. engine speed to 1200 r.p.m. generator speed, which enables a lighter generator to be used; second, the use of the unadulterated Ward Leonard method of control, which eliminates all contactors and reversing switches in the main circuit. One of the characteristics of this method of control is that the motors, being shunt-excited, will act regeneratively whenever the locomotive descends a grade or when power is interrupted. In other words, it is similar to a mechanical transmission, not free-coasting, but requires specially designed shunt motors in place of the well-developed series motors so extensively used in traction service. The control is not automatic in the sense that the operator may overload the generator or the engine equipment, and for that reason lacks the snap the automatic control has for switching operations.

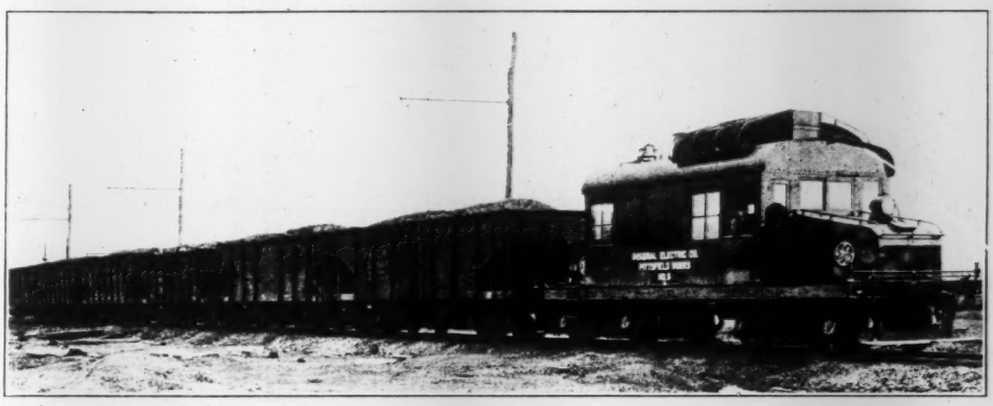

FIG. 13 GENERAL ELECTRIC 40-TON GAS-ELECTRIC LOCOMOTIVE

FIG. 14 60-TON OIL-ELECTRIC LOCOMOTIVE HAULING EIGHT-CAR TRAIN

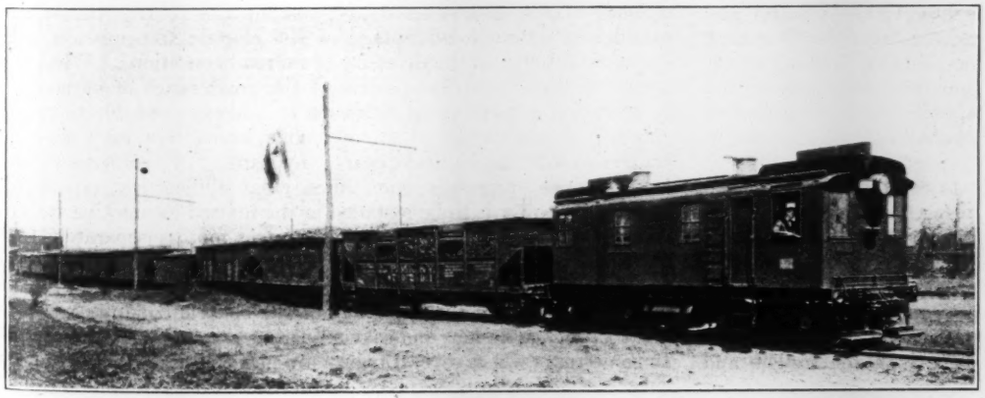

FIG. 15 60-TON OIL-ELECTRIC LOCOMOTIVE UNDER TEST WITH TRAIN

Turning to the oil-electric development in Europe, it is found that in Sweden Diesel-electric rail cars have been in successful operation for about twelve years which use substantially the constant-engine-speed control with the modified Ward Leonard in connection with reversing switches and series motors.

Similarly in Switzerland, Sulzer Bros. have been building solid-injection Diesel motor cars with electric transmission of the modified Ward Leonard type.

The most notable achievement in this direction, however, is a 1200-hp. oil-electric locomotive designed by the Russian engineer, Prof. G. Lomonossoff, a description of which has been recently published in German by the V. D. I. Publishing Dept. This locomotive, which weighs 135 short tons, has 6 driving axles and a 6-cylinder, four-cycle, M.A.N. submarine Diesel engine of 1200 hp. at 450 r.p.m. The electric transmission has been furnished by Brown-Boveri and shows the remarkable overall electric efficiency of 83 to 93 per cent. The locomotive is primarily intended for main-line service and has the modified Ward Leonard control. In order to reduce the control to a minimum weight and size, two exciters are used, one exciting the other, and in the last modification even the first exciter is being excited from a storage battery. In other words, advantage is taken of the ease with which electric force may be amplified to give an easy and wide range control to the operator.

To quote from Professor Lomonossoff's tests, "The electric losses in this thermal locomotive are extremely small," which speaks highly in favor of the electric transmission.

This locomotive when contrasted with an oil-burning locomotive of latest design with superheat and of equal power, shows a fuel consumption of only one-third that of the steam locomotive.

CONCLUSION

In conclusion, the author makes a plea for the standardizing as far as possible by railroads of their needs for service, so that manufacturers in their turn may design and manufacture equipments to conform to size and performance with such needs, as by so doing lower manufacturing, lower maintenance, and lower operating costs may be secured. The application of the internal-combustion engine

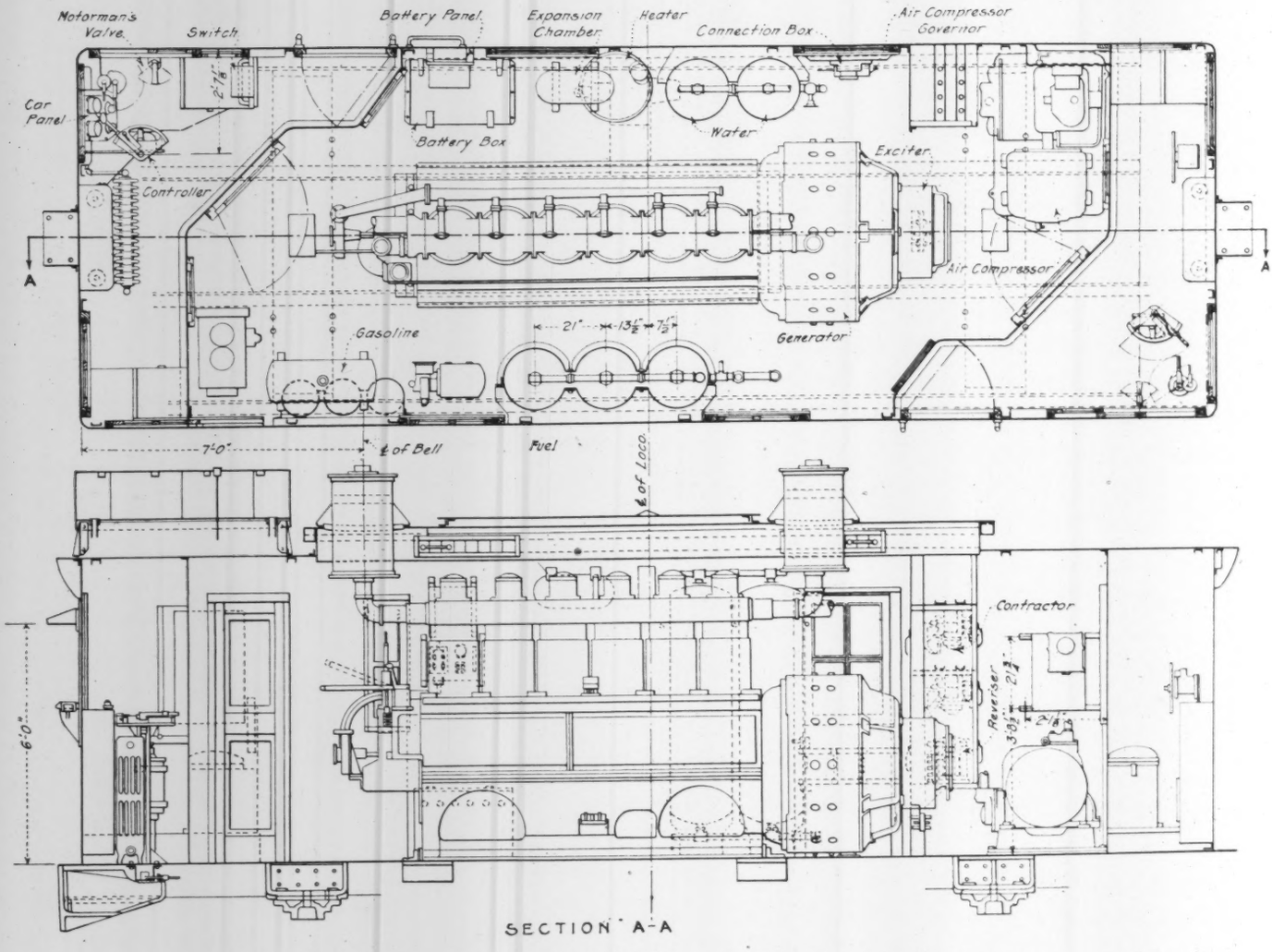

FIG. 16 LOCATION OF APPARATUS ON 60-TON OIL-ELECTRIC LOCOMOTIVE SHOWN IN FIG. 15

to traffic requirements on rails and highways is as yet in the beginning, and now is the time for manufacturers and operators to get together.

A notable precedent for such procedure was established during the war under stress of necessity. The Liberty truck motor and Liberty aviation engine were thus produced. Similarly in Germany, it is understood that the principal Diesel-engine manufacturers have evolved by a joint engineering committee some general designs of marine and stationary engines which can be duplicated in the various principal manufacturing plants to identical drawings and specifications.

Electric transmission, with its ability to coördinate with ease a number of generating units and motors, respectively, all of the same well-tried patterns, ought to lend itself particularly to this plan of mass production of units and standardization of locomotive construction.

It is believed that for buses, motor cars on rails, and switching locomotives the automatic speed-torque control has proved its economic value, and that for line locomotives, for freight and passengers, the constant engine speed coupled with generator field control through exciters will prove the more appropriate.

In advocating the electric transmission, the author believes it to be the best all-around and most efficient means of converting the energy produced by an internal-combustion engine to the ever-varying needs of traction.

Discussion

A. I. LIPETZ:[2] There is no doubt that at the present stage of the development of the oil-engine locomotive the electric transmission is the only available, the most reliable, and possibly the simplest of all transmissions. To the three advantages of electric transmission indicated by Mr. Lemp, namely, lower cost of maintenance, greater reliability, and superior control, the writer would add a fourth advantage of the electric transmission—its easy adaptability to the diversity of railroad conditions. What he means to say is that irrespective of the great range of variations in operation conditions on railroads, it is always possible to work out a practical design of an oil-engine locomotive with electric transmission. Mechanical gears, hydraulic or compressed-air transmissions, represent sometimes great difficulties, especially when large power is to be installed in the limited locomotive space; whereas the possibility of placing electric motors separately for each axle and in close proximity to it, of placing the generator, or generators, in practically any available space above the locomotive frames, and the flexibility of the electric conduits, permit great variety in designs and easy adjusting to railway requirements. In some cases where several trucks are needed on account of sharp curves, the electric transmission seems to be the only solution due to the possibility of placing the motors in direct connection with the driving wheels.

This advantage of the electric transmission is of very great importance for the development of oil-engine locomotives for reliable and effective railroad service, and if the efficiency of the electric transmission were as high as Mr. Lemp puts it in his paper and his conclusions, the writer thinks there would be no chance for any transmission to compete with electric drive; all attempts in designing and building oil-engine locomotives with other transmissions, or with a direct drive, had to be given up as hopeless.

Unfortunately, the efficiency of the electric transmission is much below Mr. Lemp's figure, and this explains the persistent attempts

[2] Consulting Engineer, American Locomotive Company, Schenectady, N. Y. Mem. A.S.M.E.

which are being made in order to develop a high-efficiency transmission of the differential hydraulic class, or an oil-engine locomotive with a direct drive. The electric transmission, even with the automatic speed-torque control, gives an efficiency of about 75 per cent, and at low speeds even less than that. The writer does not agree with Mr. Lemp in his statement that the Russian oil-electric locomotive which has the modified Ward Leonard control showed an efficiency of 93 per cent. He must have been misled by Professor Lomonossoff's somewhat unusual way of estimating electric losses. Lomonossoff refers all losses not to the output of the oil-engine, as Mr. Lemp would probably expect, but to the heat content of the oil consumed in the Diesel cylinder. He does this in order to be able to make up a balance sheet of losses and net output.

A good idea of the efficiency of the electric transmission of the Russian oil-engine locomotive and of the locomotive as a whole can be obtained from the heat-balance diagram shown on page 154

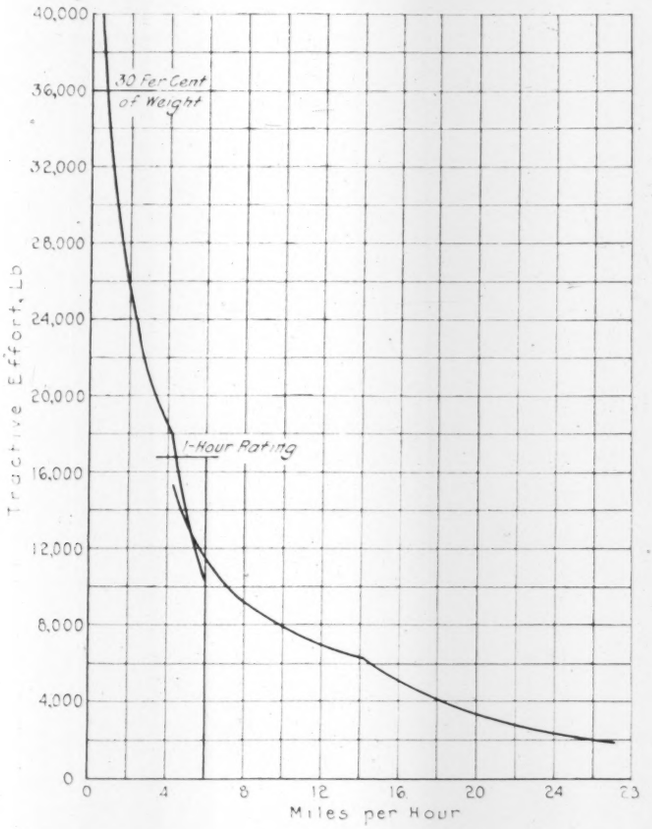

FIG. 17 TRACTIVE EFFORT-SPEED CURVE OF 60-TON OIL-ELECTRIC LOCOMOTIVE SHOWN IN FIGS. 15 AND 16

(Equipped with one Ingersoll-Rand 300-hp. oil engine and four G.E. 500-volt motors. Gear ratio, 82/14; wheel diameters, 36 in.)

of Lomonossoff's book quoted by Mr. Lemp and reproduced here as Fig. 18. Assuming the total heat content in the oil to be 1.0, the ordinates of the squared area at the top represent the losses inherent to the ideal internal-combustion cycle; the ordinates of the next lined and dotted area show losses of the actual Diesel cycle as compared with the ideal cycle. Thus the two areas together indicate the losses in exhaust gases and cylinder water jackets. The next dotted area refers to the mechanical losses in the Diesel engine as reflected in the mechanical efficiency of the engine. The dark space indicates power absorbed by auxiliaries for various speeds of the locomotive. The next narrow strip shows the electric generator losses and the last area represents the electric motor losses. Thus the net output of the oil-electric locomotive is represented by the ordinates of the white area below the lowest curve, which shows that the overall thermal efficiency at the rails, for various speeds of the locomotive, fluctuates between 18 and 26 per cent. The drawbar efficiency is, of course, less.

This diagram refers to a speed of the oil engine of 300 r.p.m. During his tests, Professor Lomonossoff found that this is the most economical speed for the Diesel engine. At its maximum output of 450 r.p.m. the efficiencies are lower. We thus see that at the speed of the Diesel engine of 300 r.p.m. the losses of electric transmission fluctuate between $4^1/_2$ and 8 per cent of the oil heat content, or between 15 and 27 per cent if referred to the power of the Diesel engine, the efficiency of the transmission being 73–85 per cent.

It is true that the *best unconditioned* transmission, as Professor Lomonssoff calls it, shows smaller losses, but this has very little practical value. The best unconditioned transmission means such unconditioned combinations of Diesel-engine speed and electric control which would give for each speed of the locomotive the best overall thermal efficiency. The power of the oil engine is then unconditionally defined, and if it should not happen incidentally to be the power required at the given speed, the combination cannot be used.

The writer desires to use this opportunity in order to correct a misstatement which is often made when quoting results, or data, on the Russian oil-electric locomotive, namely, that it is a 1200-hp. locomotive. The Diesel engine is able to develop such an output when overloaded for a short time at 450 r.p.m. At that speed, 1200 b.hp. corresponds to a brake mean effective pressure of 85.3 lb. per sq. in. It is very doubtful whether the engine can develop such high brake mean effective pressure at the speed of 450 r.p.m. for a long period of time. If we rate the engine at 72 lb. brake m.e.p., which is better suited to the speed of 450 r.p.m., than 85.3 lb., its output becomes only 1013 hp. In addition, the efficiency drops considerably at this speed. Even at 420 r.p.m. the overall thermal efficiency is only 29 per cent, which is very low for a M.A.N. Diesel engine (see Fig. 248 on p. 165 of Lomonossoff's book). Dr. M. Mayer, general manager of the Esslingen Works, where the locomotive was built, puts the output of the engine at 1000 b.hp. (see *Zeit. Ver. Deutsch. Ing.*, 1926, p. 537), and the writer thinks that this figure is more correct.

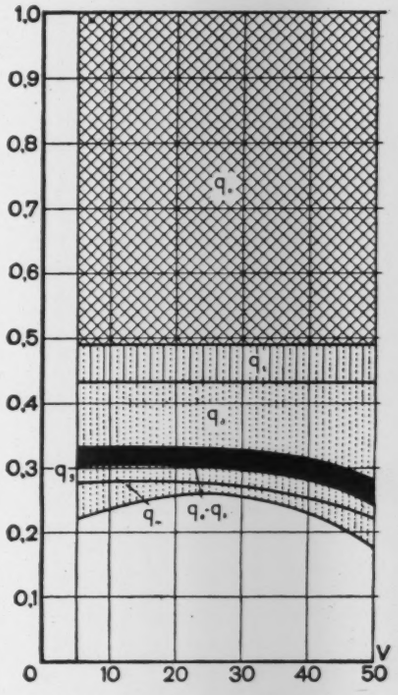

FIG. 18 HEAT-BALANCE DIAGRAM OF RUSSIAN OIL-ELECTRIC LOCOMOTIVE

This locomotive has been now for over six months in main-line freight service in Russia. It has proved to be very reliable, although some troubles resulting from overheating of electric motors on long grades were experienced. The motors are liable to get hot at high tractive efforts and speeds below 20 m.p.h., whereas the air cooling of the motors is more effective at speeds over 20 m.p.h. The locomotive cannot be used at full power, for a considerable period of time at speeds less than 10 m.p.h. In some instances, on very long grades, the speed had to be raised and the tonnage correspondingly reduced.

Nevertheless, the mileage of the Diesel-electric locomotive proved to be 85 per cent greater than that of a steam locomotive of a comparable size. The oil consumption in dollars and cents was about thirty per cent of that on steam locomotives burning fuel oil—a saving of 70 per cent. The expenses for lubrication were about six times higher than for the steam locomotive—this due to the Diesel engine—but as a whole these expenses were negligible. The cost of the crew was higher than on steam locomotives, but owing to the larger mileage of the oil-electric locomotive, it was approximately the same per locomotive-mile.

There were also some difficulties experienced with the water cooling. A special tender with cooling arrangements had to be provided for those days when the outside temperature was above 77 deg. fahr. It was then attached to the rear of the locomotive.

The total result of the operation-expense sheet showed an economy of about 26 per cent per ton-mile as compared with steam-locomotive operation.

If we consider that this was the first large-size oil-electric locomotive, the results are more than favorable.

In addition to the Russian 1000-hp. oil-electric locomotive, another 1000-hp. oil-engine locomotive has been practically completed in Germany, for use in Russia, consisting of the same M.A.N. 1000-hp. Diesel engine and a three-speed gear transmission operated by magnetic clutches. This locomotive when placed in service together with the oil-electric locomotive will give a good basis for comparison between electric and mechanical transmission.

A similar-sized locomotive with preheated compressed-air transmission is now being built at the Esslingen Locomotive Works in Esslingen, Germany, jointly with the M.A.N. firm, for use in Germany. It consists of a M.A.N. 1000-hp. Diesel engine, a compressor, and air cylinders, the air being heated by the exhaust gases from the Diesel engine.

Two locomotives are being built, one in France and another in England, on the principle of the Still combined steam and oil engine. They start under steam and give the possibility of increasing somewhat its tractive effort by means of the additional work of steam in the Diesel cylinders.

There are in Germany several oil-engine locomotives with hydraulic transmission which are universally known, and being of comparatively small power, not over 260 b.hp., they are not mentioned here.

While at present the only available transmission for immediate needs in the electric, which has proved to be a very effective solution for the oil-engine locomotive problem, much work is being done in developing other forms of transmission which should be watched with great interest.

AUTHOR'S CLOSURE

The author is greatly indebted to Mr. Lipetz's contribution and his critical analysis of the test data published by Professor Lomonossoff in connection with the 1000-hp. oil-electric locomotive purchased by the Soviet Government. In alluding to the diagram, three groups of two are furnished, representing comparative heat balances between the 1000-hp. oil-electric locomotive and the most modern Russian Type E superheated-steam locomotive of approximately the same size. The comparative groups cover normal loads, overloads, and loads most suitable for transmission. It is to this later performance as *the best possible attainable* that the author referred to when he said that it showed "the remarkable overall electrical efficiency of 83 to 93 per cent." Mr. Lipetz is undoubtedly right when he picks the normal load diagram as the practical one. Tabulating the six diagrams, we have the following:

THERMAL EFFICIENCIES (PER CENT) OF 1000-HP. OIL-ELECTRIC LOCOMOTIVE UNDER VARIOUS CONDITIONS IN COMPARISON WITH SUPERHEATED-STEAM LOCOMOTIVE

	Normal Load Min.–Max.	Overload Min.–Max.	Best Conditions Min.–Max.
Steam	7– 8	7– 9	7 – 9.5
Oil-electric	22–25	22–23	24 –26
Electric efficiency of transmission	71–84	85–87.5	83.4–93

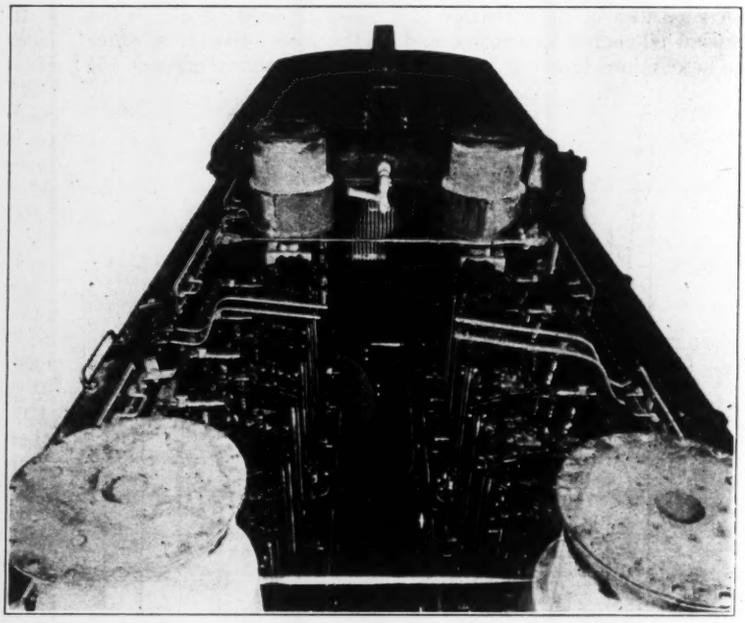

FIG. 20 100-TON OIL-ELECTRIC LOCOMOTIVE; LOOKING DOWN IN HATCH TOWARD NO. 2 ENGINE

FIG. 19 OIL-ELECTRIC LOCOMOTIVE LEAVING ERIE DECEMBER 15, 1925, ON RUN TO GREENVILLE, N. J.

The three 60-ton oil-electric switching locomotives in use in New York City have a maximum electric efficiency of 79 per cent at 14 miles per hour, and an average of 76 per cent between 8 and 32 miles per hour.

Commenting on the above, the author wants to refocus the reader's attention on the comparative performance of the Brill No. 75 mechanical car and the Electro-Motive Company's demonstration car where it is admitted that for definite speed ratios the mechanical transmission is more efficient than the electric, yet the sum-total efficiency of transmission under varying conditions is greater in favor of the electric. The highest efficiency is of no value if it applies only to some definite conditions and cannot be obtained when most needed.

This paper was forwarded to New York on November 1, 1925, and read in abstract form on December 1, at a time when one of the most interesting oil-electric locomotives was undergoing demonstration tests at Erie. A 100-ton locomotive for the Long Island Railroad with two generator units on board proved beyond question the stability of operation when using power units with drooping field characteristics connected in multiple to a common busbar.

To prove this stability one of the six-cylinder engines had purposely two of its cylinders put out of action and the two units divided their load in the proportion of four to six. This same locomotive not over two weeks later pulled a freight train of 375 tons a distance of 513 miles from Erie to New York without taking on fuel or water, without creating any noise or smoke and with a fuel consumption of only one gallow (costing 5 cents) per train-mile.

These tests have confirmed the author's previous contention that there is no limit to the size of oil-electric locomotives when multiple-generator units are used and through the employment of electric transmission, standardization of locomotives is thereby made possible.

Synthetic Ammonia

AMMONIA in one form or another has been known from the very earliest of times. It was first isolated by Priestley in 1774. In 1777 Scheele showed that it contained nitrogen, and about 1785 Berthollet finally ascertained its definite composition to be one part of nitrogen to three parts of hydrogen by volume. However, ammonia had not much commercial interest until Liebig brought to the world's attention the irreplaceable value of nitrogenous compounds in the cycle of life, beginning his work along this line about 1840.

In 1898 Wm. Crookes called attention to the fact that the beds of Chile saltpeter, which has been the largest source of natural nitrates, must eventually be exhausted and that some method must be developed for the utilization of atmospheric nitrogen, or the world would face ultimate starvation due to the depletion of nitrogenous fertilizers. This statement attracted world-wide attention and seemed to give the necessary stimulus to start constructive work on this problem. As a result almost innumerable schemes have since been proposed.

The first process to show any promise was the so-called Arc process, wherein air, which is essentially a mixture of nitrogen and oxygen, was passed through electric arcs where, under the influence of the high temperature, a certain amount of these two gases were combined to form oxides of nitrogen, which upon absorption in water and further oxidation produced nitric acid.

The next process to receive any considerable attention was the Cyanamid process. In this process lime and coke are heated in electric furnaces forming, under the action of this intense heat calcium carbide. This, when in a finely divided state and heated to a high temperature in the presence of nitrogen, combines with it to form calcium cyanamid. If heated with steam under pressure, it is broken down with the production of calcium carbonate and free ammonia. Here we have the first commercial process yielding us fixed nitrogen in the form of ammonia with any degree of ease.

The author discusses the various processes of ammonia synthesis. He mentions among the first the so-called cyanide process. If sodium carbonate together with carbon is heated in an atmosphere of nitrogen in the presence of iron as a catalyzer, the carbon and nitrogen unite with the soda to form sodium cyanide with the liberation of carbon monoxide. Sodium cyanide treated with steam liberates ammonia, with the regeneration of sodium carbonate or formation under certain conditions of sodium formate. From this the author proceeds to the considerations of processes of direct synthesis of ammonia, such as the Haber and Claude processes. The Casale process, comparatively little known in this country, is of interest. Casale uses in a somewhat larger catalyzer bomb, pressures of the same order of magnitude as Claude (around 900 atmos.). In circulating his gases he permits a regulated amount of ammonia to recirculate with his uncombined gases. The presence of this ammonia controls the rate of reaction, by which he again may control the temperature of the catalyzer. Casale obtains his gases in a rather novel way, using electrolytic hydrogen and preparing his nitrogen by burning a mixture of air and an excess of hydrogen in a suitable burner which completely consumes oxygen of the air leaving a mixture of hydrogen, nitrogen, and water vapor, the latter being condensed out. On first thought this would seem to be an expensive process, but it is to be remembered that due to the extreme purity of the gases so obtained a very elaborate, cumbersome, and troublesome purification equipment required in other processes is completely eliminated.

In this country a chemical company has been working on the synthesis of ammonia for some time, and during the late war the Government, with the company's assistance, undertook the erection of a synthetic plant at Sheffield, Ala. This plant in general essentials is very similar to the Haber process. However, there had been developed an active catalyzer that permitted reasonably efficient operation at pressures of only 100 atmos. This was also aided by the fact that the ammonia was removed by condensation, which left the system free from water vapors. However, operating at 100 atmos., it was necessary to condense the ammonia out at a considerably lower temperature than is required when the high pressures, such as Claude and Casale used, are employed. The low temperatures were obtained by expanding a certain amount of the ammonia produced. The armistice was signed before this plant got into commercial production. However, since then a commercial plant has been built along the same lines in Syracuse, N. Y.

Since the close of the war, the Government, at the Fixed Nitrogen Research Laboratory, has continued the study of the production of synthetic ammonia. In this work they have been operating a small unit, and from their experience in the operation of this unit have designed a small commercial unit capable of producing three tons of ammonia per day, a detailed description of which can be found in the August, 1925, number of *Industrial and Engineering Chemistry*. In this they prepare their mixed gases similar to Casale by burning the oxygen out of the air with electrolytic hydrogen. They operate at a pressure of 300 atmos. and a temperature around 475 deg. cent. Mixed gases are passed through a purification tube containing heated ammonia catalyzer, then through the catalyzer bomb proper, and through water condensers to condense most of the ammonia. The mixed gases and liquid ammonia then go through the circulating pump, wherein the ammonia itself acts as lubricant for the pump, eliminating the necessity of other lubricants which might contaminate the gases, then to the final condensers and ammonia receivers, the residual gas being recirculated with sufficient fresh gas to keep the pressure of the system up to 300 atmos.

The Casale process is represented in this country by an installation at Niagara Falls. The Claude process is under consideration by another company. In addition to this, there are two or three other small, what might be termed experimental or semi-commercial, units in existence.

There is no question that the direct synthesis of ammonia has completely revolutionized the ammonia industry. With ammonia of the purity of synthetic ammonia available in reasonable quantities, economic law will work to force its use in all places where a product of highest purity is required. This high degree of purity is obvious from its very method of production, while ammonia produced from any natural source can be originally recovered with innumerable impurities that require a very elaborate and complicated system to remove before a product of reasonable purity can be obtained. This brings up the question of what disposal will be made of this less pure form of ammonia. Fortunately, for agricultural uses, that is, for fertilizers, no great degree of purity is required, so the natural trend will be for the poorer grades to be consumed in this market. One more thought. The term "synthetic," due to a misconception, has come to carry with it a suggestion of inferiority. Careless use has permitted the term to be given a meaning more nearly conveyed by the word "imitation." The point the author wishes to make is this. Synthetic ammonia is pure and true and ammonia, and in no sense an imitation. In every way, chemically physically, it is identical with pure ammonia from whatever source obtained. (J. R. Powell, Chief Chemist, Armour Ammonia Works, Chicago, Ill., in *Refrigerating Engineering*, vol. 12, no. 6, Dec., 1925, pp. 180–183, *g*)

Radiation in Boiler Furnaces[1]

Radiant-Heat Data on Locomotive and Water-Tube Boilers Fired with Various Fuels, and the Development Therefrom of a Simple Formula That Permits of Results Being Predicted with a Considerable Degree of Accuracy

By GEO. A. ORROK,[2] NEW YORK, N. Y.

THE absorption of radiant heat in boiler furnaces has long occupied the attention of engineers and physicists, the latter making much the larger number of experiments and producing many papers and reports. In consequence a rather complicated theory has been evolved that depends on the accurate measurement of high temperatures in the furnace, which latter remains up to date a very difficult proceeding. Such work as that of Nicolson, Callendar, and others, the paper by Wohlenberg,[3] and such books as those of Roszak, Münzinger, and Fry serve but to emphasize the difficulties of any rational method of calculating radiant-heat absorption in such a complex situation as a boiler furnace.

But the problem is still with us and a solution must be reached, empirical if not rational, since the increasing demands on boiler surface have made water-cooled walls, water screens, radiant-heat superheaters, and other devices a practical necessity. The use of powdered coal as a fuel has increased both the need and difficulties. Fortunately among all the experimental work recorded there are a number of experiments in which the radiant surfaces were isolated, and from these it is possible to secure data on transmission of heat which are sufficiently accurate for an empirical solution over a wide variety of conditions.

Locomotive-Boiler Radiant-Heat Data

D. K. Clark in his book on the steam engine quotes many experiments where such data were secured. He begins with Nicholas Wood's account of the work of George and Robert Stephenson while developing the boiler for the famous *Rocket* in 1828, followed by other experiments with qualitative results. But he finally quotes the work of Couche and Havrez in 1874 on a Chemin de Fer du Nord locomotive boiler, cut into five parts and fed by five feed pumps. Fifteen tests were run, five with coke and five with briquets with all the tubes in service, and five with briquets with half of the smoke tubes plugged. The tests bear internal evidence of careful work and are believed to be substantially correct. Values of C_r, the coal burned per square foot of radiant surface, vary from 5.68 to 13.45 with transmissions of from 23,150 to 51,700 B.t.u. per sq. ft. per hr. W. F. M. Goss, Past-President of this Society, in 1912 reported 21 tests of locomotive boilers where the firebox surface was segregated from the tubes. The tests were very carefully made, with all the refinements of modern testing, using two qualities of bituminous coal as well as oil. Here the values of C_r varied from 3.09 to 21.02 with transmissions of from 25,790 to 57,250 B.t.u. per sq. ft. per hr.

Water-Tube-Boiler Radiant-Heat Data

Rowan, in his Modern Steam Boiler, quotes the work of Bertin on a Niclausse boiler in which each bank of tubes was isolated. He gives six averages with briquetted fuel where the values of C_r varied between 2.9 and 17.4 with transmissions of from 11,320 to 47,700 B.t.u. Burstall and Cockburn, in the discussion of Dalby's paper[4] on the Transmission of Heat, quote a test of a Belleville boiler in which each row of tubes was segregated. Here the value of C_r is 6.98 and the transmission is 41,300 B.t.u.

In a report of a test of an Atmos boiler[5] the value of C_r is given as 10.8 and the transmission as 38,300.

Thomas E. Murray, in a recent paper presented to the Association of Edison Illuminating Companies, has given the results of tests at Waterside and Sherman Creek. At Waterside two 4-in. tubes were installed about 6 in. below the lower row of tubes and tested for heat transmission by passing a stream of cold water through them. The observed transfers averaged 56,000 B.t.u. and the coal burned per square foot of radiant surface = C_r = 11.0, within a fair degree of accuracy.

A 5-sq. ft. side-wall box was installed on one side of the furnace. At C_r = 15.2 a transmission of 66,000 was secured. A 140-sq. ft. side-wall box was installed on another boiler and at C_r = 7.94 a transmission of 43,000 was secured. In all of these cases it is assumed that the standard B. & W. spacing allows 496 deg. of surface of the two lower rows of tubes to "see" the radiating surface, and the coal per square foot of radiant surface, C_r, is calculated on this supposition. This works out to 1.38 times the surface of the lower row of tubes which are exposed to the radiant action of the furnace.

At Sherman Creek one of the pulverized-coal-fired boilers, provided with Murray fin-tube water walls, radiant-heat superheaters, and water-cooled burner boxes, was used in tests. Each kind of surface was on a separate feed pump except the superheater, and fifteen very accurate tests were obtained. The coefficient for the radiant-superheater surface varied between 0.4 and 0.6, but in the calculation 0.5 was used throughout. In these tests the values of C_r varied between 3.38 and 8.21, with transmissions between 20,900 and 48,500. Two kinds of pulverized bituminous coal were used.

Discussion of the Data

We now have data on three designs of locomotive boilers, four designs of water-tube boilers, and one design of revolving boiler, the Atmos. We have data on high- and low-volatile bituminous coal, briquets, coke, powdered fuel, and oil as fuel, with hand-fired stoker and other types of firing mechanisms. These are given in Table 1. From such a collection of data it should be possible to work out a formula which would permit of results being predicted with a reasonable degree of accuracy, and at the same time permit of the checking up of boiler tests when the radiant surface was not isolated from the circulatory system of the boiler, and which at the same time would allow for the determining of the convection fraction of the heat and the temperatures which might be observed in the tube bank and uptakes. A search through the literature of radiation revealed many theoretical attempts to solve the problem (without actual data), and one empirical attempt to check results which seemed to offer promise. This was the work of J. G. Hudson, published in *The Engineer* (London), December 26, 1890, and reprinted in Bryan Donkin's Boiler Tests and Rowan's Modern Steam Boilers. Hudson's formulation was rather involved, but could be simplified when certain additional data were known. His theory was that the transmission by radiation was proportional to the coal burned per square foot of radiant surface, and that the furnace temperature was inversely proportional to the pounds of air per pound of fuel.

Let S_t = total boiler surface, sq. ft.
S_r = radiant surface (equivalent), sq. ft.
C = coal burned per hour, lb.
H_c = B.t.u. in coal per pound
H_a = available heat per pound of coal
= H_c — loss (H, H_2O, CO, combustible in ash, etc.)
A = pounds of air per pound of coal.

Then $C/S_r = C_r$ = pounds of coal per square foot of radiant surface

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[1] Discussion of a paper entitled Radiation in Boiler Furnaces, by B. N. Broido, presented at the A.S.M.E. Annual Meeting, New York, Nov. 30–Dec. 4, 1925, and published in abridged form in Mechanical Engineering, February, 1926, pp. 133–137.

[2] Consulting Engineer. Mem. A.S.M.E.

[3] Presented at the A.S.M.E. Spring Meeting, Milwaukee, Wis., May, 1925. See Mechanical Engineering, vol. 47, no. 8, Aug., 1925, p. 627

[4] Proceedings of the Institution of Mechanical Engineers, 1909, Parts 3–4, pp. 1045–1046.

[5] *Zeitschrift des Vereines deutscher Ingenieure*, vol. 69, no. 7, Feb. 14, 1925, p. 169–173.

TABLE 1 DATA FOR RADIANT HEAT

	S_r	C_r	X
Robert Stephenson about 1834 D. K. Clark			
Coal	6	7.67	15,500
Chemin de Fer du Nord, Couche and Havrez D. K. Clark and Rowan			
Coke	76.5	5.71	23,150
	76.5	8.55	30,490
	76.5	9.53	33,600
	76.5	10.4	33,700
	76.5	10.1	27,300
Briquettes	76.5	6.25	27,200
	76.5	9.72	35,500
	76.5	12.1	44,200
	76.5	13.45	49,600
	76.5	12.8	45,000
	68.0	5.68	30,600
	68.0	8.95	34,800
	68.0	10.35	45,800
	68.0	11.6	50,500
	68.0	12.4	51,700
Goss, Jacobs-Shupert, and Radial Fire Box			
Bituminous Coal	230.8	5.93	25,840
	230.8	7.18	29,190
	230.8	11.16	37,600
	230.8	13.39	41,290
	230.8	18.82	50,360
	230.8	19.35	50,600
	206.7	8.51	33,900
	206.7	7.03	29,950
	206.7	11.96	36,300
	206.7	14.17	46,200
	206.7	21.02	57,250
	206.7	20.68	51,660
Oil	230.8	3.09	25,790
	230.8	6.10	43,810
	230.8	5.87	38,790
	230.8	9.05	49,140
	230.8	8.88	47,100
	206.7	3.32	32,450
	206.7	6.32	45,750
	206.7	6.05	51,360
	206.7	8.85	56,040
	S_r	C_r	X
Niclause Boiler, Bertin			
Briquettes	74.2	2.9	11,320
	74.2	5.8	22,100
	74.2	8.7	30,000
	74.2	11.6	36,900
	74.2	14.5	42,700
	74.2	17.4	47,700
Belleville Boiler, Burstall and Cockburn			
Coal	85	6.98	41,300
Atmos Boiler, V. D. I.			
Coal	140	10.8	38,300
Murray, Waterside			
Coal	352.8	11	56,000
	251	15.2	66,000
	479	7.94	43,000
Murray, Sherman Creek No. 10			
Powdered Coal	966	3.38	22,225
	966	3.38	20,900
	966	3.77	24,800
	966	3.92	25,225
	966	3.94	23,600
	966	4.22	24,800
	966	4.7	29,500
	966	5.14	32,050
	966	5.38	30,525
	966	5.7	32,700
	966	6.8	43,700
	966	8.21	44,500
	966	7.73	42,700
	966	7.95	48,500
	966	8.1	44,400

$1/C_r = F$ = square feet of radiant surface per pound of coal burned

X = heat transmission per square foot of radiant surface per hour.

Hudson's formula reduced to

$$X = \frac{H_a}{F}\left(1 - \frac{A}{A + 45F}\right)$$

This formula did not suit the known facts and was first modified by a term including the rate of running or the percentage of running with a modification of the constant. The formula then became

$$X = C_r H_a \left(1 - \frac{A}{A + 42.5\sqrt{rF}}\right)$$

where the boiler rating r is a fraction.

Further investigation and more data enabled a further simplification and the following expression seems to fit all data fairly well:

$$X = C_r H_a \left(\frac{1}{1 + \frac{A\sqrt{C_r}}{27}}\right)$$

The graph plotted on X and C_r as y shows the location of all data which have been secured up to date.

The expression

$$\frac{1}{1 + \frac{A\sqrt{C_r}}{27}}$$

is the fraction of the available heat in the furnance which is transmitted by radiation. The fraction

$$1 - \frac{1}{1 + \frac{A\sqrt{C_r}}{27}}$$

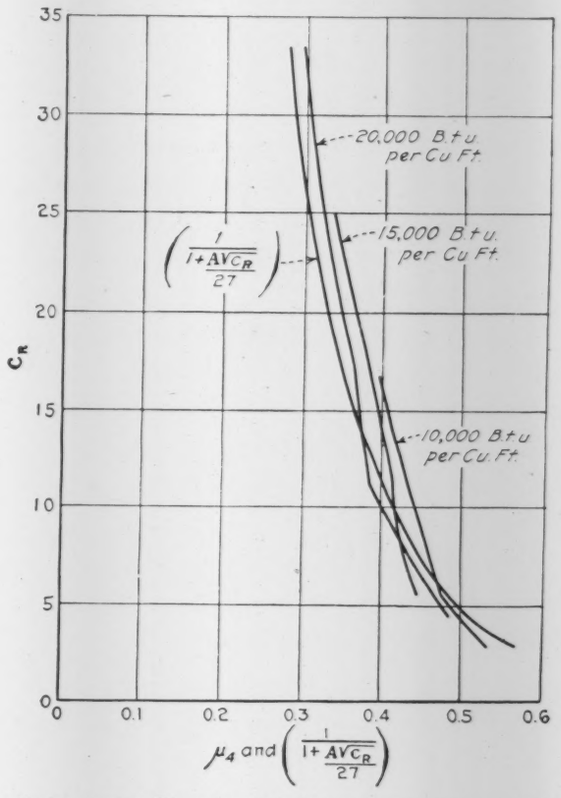

FIG. 1 COMPARISON OF WOHLENBERG'S COEFFICIENT μ_4 WITH THE HUDSON FORMULA MODIFIED BY ORROK

μ_4 = per cent of B.t.u. liberated absorbed by radiant surface.

$\frac{1}{1 + \frac{A\sqrt{C_r}}{27}}$ = fraction of B.t.u. liberated absorbed by radiant surface.

is the fraction of the available for convection heat at the entrance to the convection surface and the temperature at this point must be:

$$t_c = \frac{H\left(1 - \frac{1}{1 + \frac{A\sqrt{C_r}}{27}}\right)}{0.25(A + 1)} + \text{temp. of draft} = \text{temp. entering convection surface.}$$

If the flue temperature t_f be known, then

$h = (t_c - t_f)0.25(A + 1)$ = B.t.u. per lb. of coal absorbed by convection.

The B.t.u. per lb. of coal absorbed by radiation are

$H_a\left(\frac{1}{1 + \frac{A\sqrt{C_r}}{27}}\right) = H$, and $\frac{H + h}{H_c}$ = boiler efficiency, thus

giving a check which may be applied to boiler tests. This check is not as good as it should be since it is affected by after-burning of CO and by leakage into the boiler beyond the furnace.

In the discussion of Wohlenberg's paper at the Milwaukee meeting (1925) the writer called attention to how closely Wohlenberg's rational figure for μ_4 agreed with his modification of Hudson's empirical formula, see Fig. 1, but the most interesting check is obtained through well-conducted boiler tests where the "radiation and unaccounted for" percentage is positive and reasonably small. (See Fig. 2 and Table 2.) It has been tried on many of these tests from many sources with rather remarkable results, as the variation is usually much less than the "radiation and unaccounted for" item. Some few examples are given in Table 2.

It should be observed that such convection heat as affects the radiant surfaces is considered as radiant heat, and such radiation from the gases as affects the convection surfaces is considered as convection heat. The convection temperature t_c in consequence may not be quite correct. However, the variations are not nearly as large as observed pyrometer variations, and the obtaining of accurate average furnace and flue temperatures is still an unsolved problem.

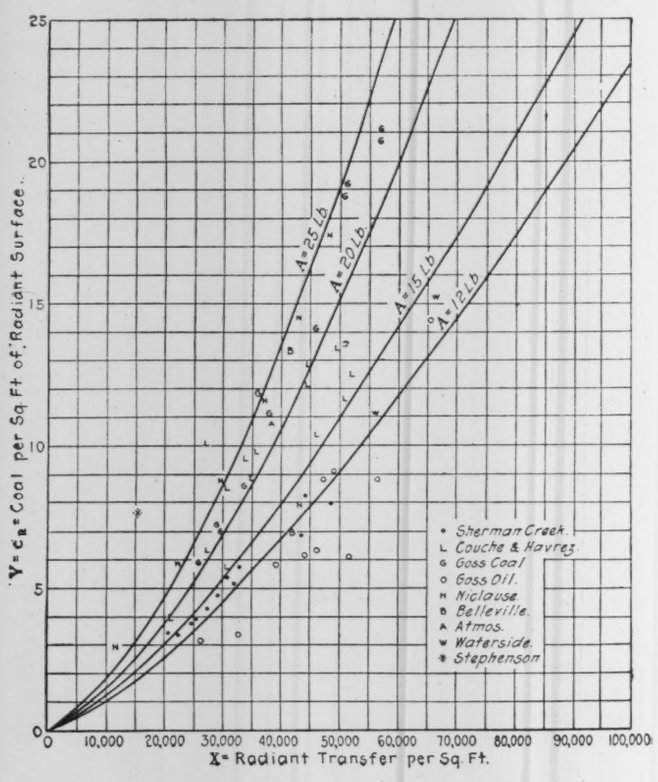

FIG. 2 RADIATION DATA AND CURVES FROM FORMULA

TABLE 2 SAMPLE CHECKS OF BOILER TEST RESULTS USING ORROK'S MODIFICATION OF HUDSON'S FORMULA

Station	Hell Gate		Lake Side		Conners Creek		Lansing	
No. of test	1	2	22	12	64	62	60	4
Boiler	Springfield		Edgemoor		Stirling		Heine	
Rating	170	228	167	241	59	142	196.4	294
C_r	3.66	5.07	6.36	9.87	1.92	4.67	6.74	10.1
$\sqrt{C_r}$	1.915	2.25	2.52	3.14	1.386	2.161	2.597	3.18
A	16.55	16.71	10.8	11.5	12.72	10.45	10.51	11.9
$\frac{1}{1+\frac{A\sqrt{C_r}}{27}}=\mu_4$	0.461	0.433	0.497	0.428	0.605	0.544	0.498	0.417
H_c	14261	14117	12544	12217	12549	12240	12200	13297
H_a	13480	13350	11880	11370	11621	11274	11042	12400
N	22800	29300	37600	48000	13500	28660	37050	52200
$0.25(A+1)$	4.39	4.18	2.95	3.125	3.43	2.86	2.88	3.23
$H=H_a\mu_4$	6220	5780	5900	4780	7030	6.135	5493	5170
H_a-H	7260	7570	5980	6500	4591	5139	5549	7230
$\frac{H_a-H}{0.35(A+1)}$	1650	1810	2026	2080	1338	1797	1927	2240
t_i	80	80	96	105	86	86	80	69
t_c	1730	1890	2122	2185	1424	1883	2007	2309
t_f	455	506	463	528	407	526	601	712
t_c-t_f	1275	1384	1659	1657	1017	1357	1406	1597
$h=(t_c-t_f)$ $.25(A+1)$	5600	5780	4895	5180	3490	3881	4050	5150
$H+h$	11820	11560	10795	10050	10520	10016	9543	10330
Cal. eff., per cent.	82.9	81.7	86.1	82.2	83.8	81.9	78.2	77.7
Test eff., per cent.	83.2	80.4	86.2	82.3	80.9	81.7	78.5	77.2
Radiation and unaccounted for test	+0.09	+3.06	+0.5	+1.8	+2.1	+0.5	+0.5	+1.82

Murray's curve is plotted with the unit transfer as abscissas and the total heat absorbed by the boiler per square foot of radiant surface as ordinates. Wohlenberg's μ_4 has the heat of the coal per square foot of radiant surface as ordinates while the fraction absorbed as radiant heat appears as abscissas. Broido uses the same coördinates. The writer has felt that on a plot such an attempt at accuracy was not warranted and used C_r as ordinates with either $\mu_4 = \frac{1}{1+\frac{A\sqrt{C_r}}{27}}$ or the unit radiant absorption as abscissas.

All of these diagrams are good, but the modified Hudson formula is simple and so quickly worked on the slide rule that the diagrams are only good for comparison, a simple calculation giving all necessary quantities to check a complete boiler test or new design.

In conclusion it must be stated that, whatever formulation or curve be used, the value of μ_4 or the fraction of heat utilized as radiant heat varies between 0.0 in waste-heat boilers to over 0.750 in certain experimental calorimeters, while the ordinary range lies between 0.250 and 0.600.

Hydroelectric Progress in Canada During 1925

HYDROELECTRIC and water-power development in Canada reached record proportions during the year 1925, the increase in the total installation far exceeding that of any previous year. This is indicated by the review of the year's activities prepared by the Dominion Water Power and Reclamation Service of the Department of the Interior, whose records show that 719,000 hp. was added during the year bringing the total installation in the Dominion to 4,290,000 hp. Many projects are also under way which will add more than 250,000 hp. in the early part of 1926.

Not only was 1925 of outstanding interest on account of the large increase in installed capacity, but it marked the bringing into operation or completion of a number of large projects which have been under active construction for the past few years. Of these the most notable are the Queenston development of the Ontario Hydroelectric Power Commission on the Niagara river with 500,000 hp. completely installed, and the development of the Duke-Price Power Company on the Saguenay river in Quebec which brought into operation 360,000 hp. of an ultimate capacity of 540,000 hp. While the next year or two are not expected to witness as large increases as 1925 there are projects of great magnitude now under way or in early prospect which will provide substantial additions as they are brought into operation. These include the 800,000-hp. development recently commenced at Chute a Caron on the Saguenay river by the Aluminum Corporation of Canada, and a project of almost the same ultimate proportions on the Bridge River in B. C. by the British Columbia Electric Railway Company. Numerous other developments of lesser capacity have either been commenced or are in early prospect so that there is every assurance that the average growth of the past few years will be well maintained in the future.

Quebec led with a total installation of 438,300 hp. largely contributed by the development of the Duke-Price Power Company, Ontario, followed with almost 200,000 hp. contributed chiefly by the Queenston development of the Ontario Hydro-Electric Power Commission. Other provinces having important additions were British Columbia with 58,984 hp. and Manitoba with 21,900 hp.

The 58,984-hp. net addition to British Columbia's total during 1925 was contributed by the Stave Falls plant of the British Columbia Electric Railway Company, and the Lower Bonnington Falls plant of the West Kootenay Light & Power Company.

At Stave Falls on the Stave River the British Columbia Electric Railway Company brought to completion work begun in 1922 which involved the trebling of the storage capacity in Stave Lake both by the raising of the lake level 22 ft. by new dam construction and by diverting the waters of Alouette Lake to Stave Lake by the construction of a tunnel. Due to the increase in head and the additional water supply a fifth unit of 15,000 hp. was added during 1925 to the plant and the other four units raised to the same capacity, necessitating the rewinding of the existing generators. The net increase in capacity amounted to 23,000 hp.

Fusion-Welded Pressure Vessels

The Reliability of Present-Day Fusion Welding—Proposed Code for Fusion-Welded Pressure Vessels, Based on Use of the Latest Practices and Methods—Specifications for a 60-In. Fusion-Welded Tank 20 Ft. Long for a Working Pressure of 200 Lb.

By S. W. MILLER,[1] LONG ISLAND CITY, N. Y.

WHILE engineering has been defined in many ways, the fundamental idea involved in the use of the term is that it is concerned with the employing and developing of the materials and forces of nature for the use of mankind, an engineer being one who is occupied with this work.

There is not, and cannot be, a sharp line of division between any two of the many fields of engineering, but in a general way mechanical engineers are concerned with machinery, boilers, engines, and their appurtenances, among the latter being piping and containers of various kinds.

The applications of fusion welding to these structures have been great both in number and size, and many of them have been in successful operation for a long enough time to make it almost certain that no trouble will arise in the future in any of these cases, and to warrant an increase in the number, size, and kind of applications of the processes.

An engineer controls the materials and structures he works with by means of specifications. He draws up these specifications from his own experience and that of others, including the results of well-planned and executed tests, so that by using good judgment he is able to obtain the results he desires. It may well be that in some cases he does not have all the information he needs, but that does not deter him, as he always finds ways to get what he wants.

Further, if any design, construction, or process is advantageous, it is the duty of the engineer to learn about it and use it when and where he can. This may require some study, but one of the engineer's most precious privileges is to investigate and learn.

Now with regard to fusion welding in general, it seems to the author very clear that the advantages of the processes make it incumbent on the engineer to study them thoroughly, so that he may use them intelligently, and that he is not fair to himself unless he does so.

It is admitted by all those to whom the author has talked that good welding can be and is being done. To deny this would be to deny facts. If it is being done, some one must know how to do it, and so he would be rash indeed who would say that engineers could not draw up specifications that would insure good welding.

A code differs from a specification in that it governs all specifications, and in that it is written primarily as a safety measure. In other words, the author's conception of a code is that it is a description of the minimum allowable requirements for safety. But a code must not contain requirements that are prohibitive or even unduly restrictive to the industry, if it is a fact that by the use of good material, design, and workmanship a product can be safely made that is safe. Therefore, in the author's view, there is no room nor place in a code for any restrictions based on any assumption that bad workmanship may sometimes be used.

It should be pointed out that the responsibilities of the code committee, the enforcing body, and the engineer are essentially different. They correspond rather closely to those of the legislative, administrative, and judicial departments of our Government. The code committee is the legislative, the enforcing body is the administrative, and the engineer is the judicial factor.

The code committee makes the code, and should produce one that is fair to the producer, the consumer, and the public.

It is theoretically very simple to make a code, but there are many practical difficulties in the way. These are quantitative rather than qualitative, and are usually due to a lack of definite knowledge. Mere opinions are not data, and as a code should be based on sound engineering data, such opinions are of little or no force or value. So the committee should insist on definite evidence, getting it where and how they can.

The author knows of no other code than the A.S.M.E. unfired-pressure-vessel code that contains restrictions based on the assumption of poor workmanship. While it is not denied by any one that there have been some cases of failure of welded pressure vessels due to this cause, there are thousands of welded pressure vessels that have not failed, and it is a fact that good welding does not fail.

It is bad logic to condemn fusion welding as a dangerous *process* because of these failures, unless it be admitted that failures of other types of joints due to the same cause also condemn the *processes* by which they are made. Such reasoning is obviously more harmful to the one using it than it is to the welding industry.

After the code has been made, it must be enforced if it is to be of any value, and this is the duty of the state, through its authorized representatives. It cannot be done by the code committee. Therefore, as local conditions and laws differ, each enforcing body has problems that it must solve in accordance with its own peculiar difficulties.

Further, as the state must do the enforcing, the code should not contain any references to inspection, stamping, or other matters that relate to the duties of the state. Also no attempt should be made to specify methods of doing work, tests for operators, or other similar matters. These are functions primarily of the manufacturer, and secondarily of the inspector employed by the engineer or the constituted authority.

Also, as it is the duty of the state to enforce the code, the state should do so, and not avoid its duty by trying to prohibit or unduly restrict an industry. It is probably true that there are not at the present time enough competent welding inspectors in state employ to enforce thoroughly a good code, but that is not the fault of the code, and certainly a committee should not allow itself to insert restrictions in a code for any such reason as this. Obviously if a good code were completely enforced, there could be no accidents.

The unfired-pressure-vessel code of the A.S.M.E., in the author's judgment, needs revision of the parts relating to fusion welding if it is to command the respect it should from those familiar with welding practices and possibilities. Probably the easiest way to revise would be to rewrite, and so he ventures to present a code for fusion-welded vessels, believing that, while it is doubtless not perfect, it is much more accurate and workable than the one he criticizes. It is only fair to say that changes in the most important items have been presented by the American Welding Society to the Boiler Code Committee for their consideration, and that it is expected that some modifications in the present restrictions will be made, because of the engineering evidence that accompanied the presentation, and because of the advances recently made in welding.

But it is the belief of the author that the recommendations referred to are not as liberal as would be perfectly safe, and so he has gone still further with the idea of using the latest practices and methods as a basis for the proposed code.

Experience and observation warrant the statement that at present it is no more difficult to train men to make perfectly satisfactory welds than it is to train them to make any other satisfactory product. Some may find it hard to realize this, but it is true, and it has been proven so many times in the last two or three years that to deny it would be simply to deny the facts. The welding of 140 miles of 8-in. pipe by 44 welders who made 18,000 welds in which the only defects were four pinhole leaks, which were calked, is one instance. This pipe is an oil line operating under a maximum pressure of 750 lb. per sq. in., and during a severe storm was in places washed out of the trench 20 ft. from its position. It

[1] Union Carbide and Carbon Research Laboratories, Inc. Mem. A.S.M.E.
Presented at a meeting of the Metropolitan Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, January 14, 1926.

was pulled back into place without stopping the flow of oil and without any leaking.

Another case is three tanks each 7 ft. in diameter and 35 ft. long, of $^3/_4$-in. material in the shell, with heads 1 in. and $1^1/_8$ in. thick, for 125 lb. working pressure, the hydrostatic hammer test at 375 lb. being used, under which the tanks were all perfectly tight. These were the first large welded tanks made by the manufacturer, and the author believes the largest fusion-welded pressure vessels ever made.

Still another instance is the welding of a lime-kiln shell 125 ft. long and 8 ft. in diameter of $^5/_8$-in. material. It weighed 15 tons less than a riveted one of the same shell thickness, and its alignment was well within the specification limit. It is interesting to know that the apparent fiber stress across the riveted joints was twice the stress across the corresponding welded joints, due to unavoidable movement in the riveted ones. Over two years' service has failed to develop any defects in the welds. Such instances might be multiplied, but as each one was a pioneer job, they prove the contention that good welding, even in unusual jobs, is easily obtained, provided the will to obtain it exists.

There is also submitted a specification for a definite tank, of the maximum diameter that can be made for 200 lb. working pressure with a $^3/_4$-in-thick shell, though, as noted above, larger-diameter tanks, but carrying less pressure, have been successfully

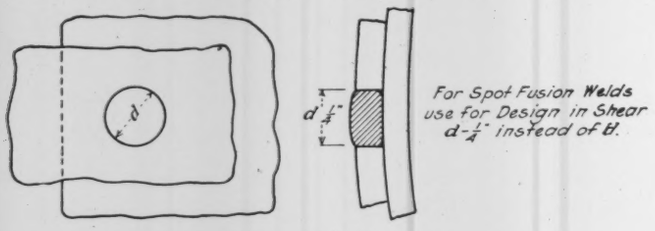

FIG. 1

made. Of course different conditions would alter the specifications, and the one given is only a guide to the engineer. It will be noticed that the requirements are more rigid in some respects than the proposed code calls for, because they embody the author's opinion of the best possible design and construction, such as might be desired in a special case.

There is also appended a list of published articles that may be of interest to the engineer, as well as to others.

PROPOSED CODE FOR FUSION-WELDED PRESSURE VESSELS

All provisions in the A.S.M.E. pressure-vessel code shall apply to the vessels covered by this code, unless such provisions conflict with those in this code, in which cases this code shall apply.

1 The term "fusion welding" in these rules shall be considered as applying to the oxyacetylene and metallic-arc welding processes, the work being done by hand, and ordinary welding materials of good quality being used.

2 Longitudinal seams shall be of the double-V type, that is, welded from each side half-way through the sheet. Girth and head seams may be of the single-V type, that is, welded entirely through from the outside. Double-V longitudinal welds shall be reinforced at the center of the weld on each side of the plate by at least 25 per cent of the plate thickness. Double-V girth welds shall be reinforced at the center of the weld on each side of the plate by at least 10 per cent of the plate thickness. Single-V welds shall extend entirely through the plate and shall be reinforced at the center of the weld by not over 20 per cent of the plate thickness. All welds shall be of sound metal, thoroughly fused to the sides of the V for its entire depth. Sheets must not be allowed to lap during welding. In material $^1/_4$ in. or less in thickness the longitudinal seams need not be beveled. In material less than $^1/_4$ in. thick, beveling the heads will be sufficient, and the shell need not be beveled at the head seams but one side of each girth seam shall be beveled.

There shall be no valley either at the edge or in the center of the joint, and the weld shall be so built up that the welded metal will present a gradual increase in thickness from the surface of the sheet to the center of the weld.

At no point shall the sheet on one side of the joint be offset with the sheet on the other side of the joint in excess of one-quarter of the minimum thickness of the plates.

NOTE: There is little if any additional cost involved in the making of a double-V seam over that of a single-V. The former is also symmetrical and so causes no eccentric loading. Further, when ordinary welding rod is used—and the code is based on its use—there is a strong tendency for defects to occur at the bottom of the V, further increasing eccentric loading.

These conditions affect girth seams very little, and the single-V weld in them and similar places is entirely reliable. It must be borne in mind that the remarks in this discussion apply to pressure vessels only, and, because of the nature of their use, the greatest refinement of design and manufacture must be used to insure safety.

3 The plate or sheet used shall be of suitable quality for welding and shall conform to the requirements of Sections U110 to U125 of the Pressure Vessel Code, or to those in Sections S5 to S17 of the Power Boiler Code, except that the carbon content shall not exceed 0.18 per cent and that the limits of ultimate tensile strength shall be from 48,000 to 58,000 lb. per sq. in.

NOTE: The materials specified for sheets and plates in Section U71 are, in the author's judgment, satisfactory, except that he would limit the carbon content to a maximum of 0 18 per cent in the cases of flange and firebox steels. The reasons are,

1 The lower the carbon in the steel, the less is it injured by heat and mechanical work.
2 The lower the carbon, the better the distribution of welding stresses.
3 The lower the carbon the higher is the relative strength of the weld, and the tendency to break in the plate, until with 0.15 per cent carbon plate, low-carbon steel welding wire, and reasonable reinforcement of the weld, the plate will always break.

There is a tendency to speak of the efficiency of a weld in the same way as the efficiency of a riveted joint is referred to, but the only safe way is to make the joint more than 100 per cent efficient, and then we need not worry about the efficiency This is easily done by using the proper materials. We may further consider that while with riveted joints a greater efficiency reduces the weight of the plate, provided the same strength plate be used in all cases, yet even the highest-strength plate will not allow the efficiency to be much increased, as the shearing strength of the rivets is a rather definite quantity.

With welding, the strength of the weld is also a definite quantity in the case of any particular wire, and a 100-per cent weld in 50,000-lb. plate is just as strong as a 50-per cent weld in 100,000-lb. plate, so there is no difference in weight, while the 50,000-lb. plate has the advantages spoken of that make it much more desirable material.

4 Maximum allowable fiber stresses on welds due to internal pressure shall be as follows, per square inch of plate section.

	Lb. per sq. in.
In tension:	
Butt double-V longitudinal welds	8,000
Butt single-V girth or head welds	6,500
Double full fillet girth or head welds	7,000
Spot or intermittent fillet head welds	5,600
In shear	7,000
In compression	15,000

Where spot welds are used, as in Figs. 1 and 6, the calculation for strength shall be based on the diameter of the hole minus $^1/_4$ in.

Where fillet welds are used, as in Figs. 4, 5, 6 and 7, the calculation for strength shall be based on the length of the weld minus $^1/_8$ in., and on the thickness of the weld minus $^1/_{16}$ in., measured perpendicular to its surface.

All vessels shall be so supported as to distribute properly the stresses due to their weight and contacts. In no case shall the working fiber stresses on welds be increased, by any stresses other than those due to internal pressure, more than 500 lb. per sq. in. of plate above those allowed for that pressure.

NOTE: Section U68 allows a maximum tensile fiber stress of 5600 lb. per sq. in. for both double and single-V welds.

This is taken from test results given in Prof. R. J. Roark's paper before the A S.M.E. in May, 1922, in the table on page 26 of the preprint, and in the early drafts of the code appeared as 28,000 lb. with a factor of safety of 5. (See also Heating Boiler Code, section H70.) From the latter it is clear that the stress is per square inch of plate section.

The figure in Roark's table, however, is per square inch of weld section, and when reduced to plate section it becomes 7000. If it be fair to take it as a sound engineering datum, then 7000 should be used instead of 5600. But 35,000 lb. ultimate strength is too low for even a single-V weld made by a competent operator, as any one familiar with weld tests known, and indicates clearly lack of penetration or fusion, which would readily be seen by even superficial examination. There can be no objection to rating a single-V

girth weld at 6500 lb., the proposed figure. Double-V welds are shown by Bulletin No. 5 of the A.W.S., to be much superior both in consistency and strength to those of the single-V type, and the A.W.S. recommended that a maximum tensile fiber stress of 8000 lb. per sq. in. of plate be allowed for double-V welds. Under the test conditions described in that Bulletin, this is equivalent to a factor of safety of about 6.25. The author believes that 8000 is much too low in the light of present-day knowledge and skill, but it certainly cannot be said to be too high in view of the facts in Bulletin No. 5, and as it has been recommended by the American Welding Society, he has used it in this code.

The ultimate shearing strength of weld metal is about 40,000 lb. per sq. in., or approximately equal to that of rivet material. It is felt that a factor of nearly 6 gives ample security, especially as allowance is made in this code for possible imperfect fusion in corners of spot and fillet welds.

The lap-weld construction is known by tests made during the war to be perfectly safe, provided welding is done at both edges of the lap, or an equivalent spot weld is used. This latter is feasible with small-diameter tanks.

The compressive strength of weld metal is seldom used in tanks. As the weld is usually low-carbon steel, and as it is never the controlling factor in tank design, the figure given is safe, and is introduced for completeness.

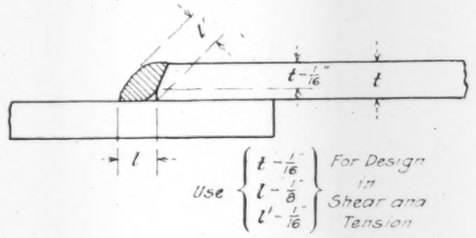

FIG. 2

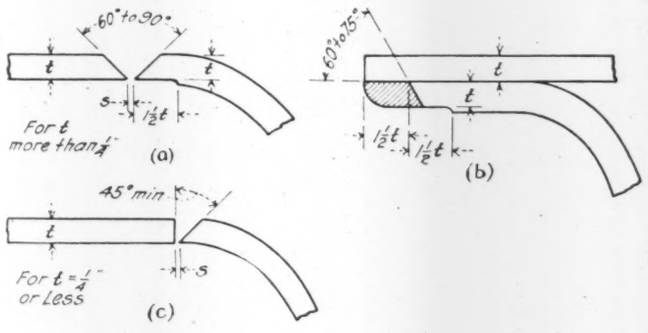

FIG. 4

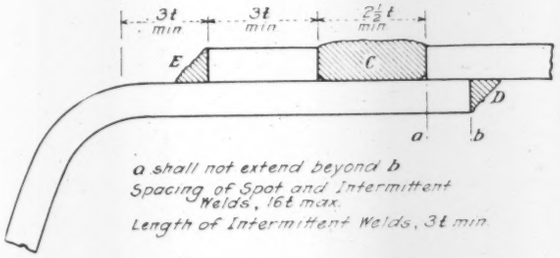

FIG. 6

5 Where vessels are made up of two or more courses with welded longitudinal joints, the joints of adjacent courses shall be not less than 60 degrees apart.

NOTE: This is the same as Sec. U72.

5a The provisions of sections U53, U54, and U62 of the A.S.M.E. code shall govern the application of manholes and handholes.

Manhole openings, if elliptical, shall be not less than 11 × 15 in. or 10 × 16 in.; if circular, not less than 15 in. in diameter.

Handhole openings, shall be reinforced as are manholes, when their greatest dimension is over 6 in.

Manhole frames shall be of wrought steel at least as thick as the plate to which they are welded, but not more than 25 per cent thicker, and if welded, shall be applied as in Figs. 7 and 9, the welds being full fillet and extending all the way around inside and outside.

The total section of the frame at any plane passing through its center shall be at least equal to the section of the plate removed along the same plane.

The outside weld shall be so designed that its tensile and shearing strengths shall each be equal to the tensile strength of the material removed from the plate.

NOTE: It has been found by stress-strain measurements that with the method of design given there are no serious stresses around the manhole

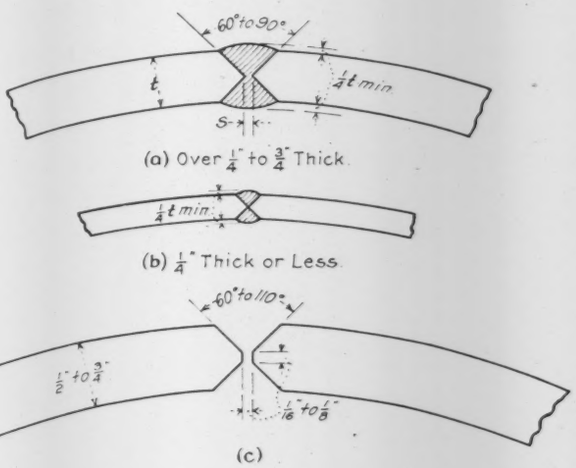

FIG. 3
(This figure gives design dimensions and is not to be used in construction.)

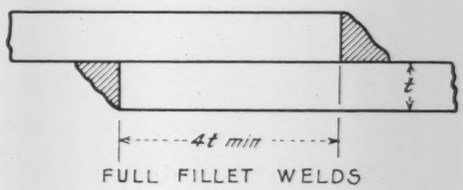

FIG. 5

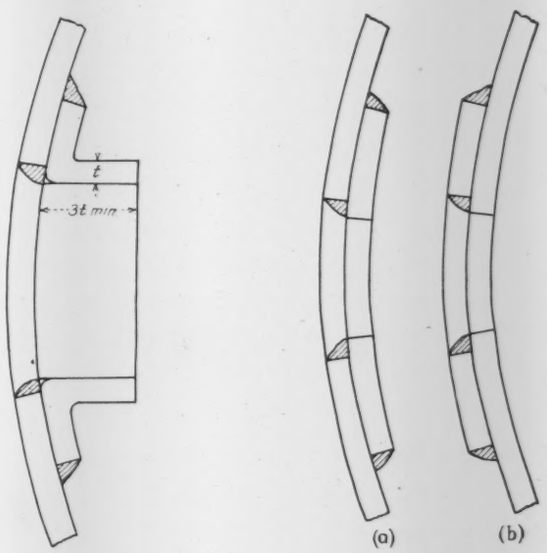

FIG. 7 FIG. 8

opening at the working pressure. The provisions are mostly copied from the A.S.M.E code, with slight changes in the wording to suit welding conditions.

6 The shell shall be substantially circular at any section.

NOTE: This is taken from Section U73, the instructions as to how to obtain the result being omitted as not belonging in a code.

7 Heads shall be dished and flanged, and shall be designed in accordance with Sections U36 to U39 of the A.S.M.E. code, except

that when a manhole frame is welded in a head in accordance with this code, no increase in head thickness will be required.

(In this code a "convex head" means one convex to the pressure, and a "concave head" one concave to the pressure.)

They shall be attached to the shell as shown in Figs. U3-J or U3-K of the A.S.M.E. code, or Figs. 4, 5, or 6 of this code.

A head inserted in a shell shall be well fitted and a driving fit therein.

The minimum length of head flanges, either convex or concave, shall be as follows:

Inside diameter of tank	Minimum straight length of flange
12 in. and less	$1^1/_4$ in.
Over 12 in to 24 in.	$1^3/_4$ in.
Over 24 in. to 36 in.	$2^1/_4$ in.
Over 36 in. to 48 in.	$2^3/_4$ in.
Over 48 in. to 60 in.	$3^1/_4$ in.

In any case in which the head is over $^1/_4$ in. thick and more than $1^1/_4$ times the shell thickness, it shall be reduced to the shell thickness as shown in Fig. U3-J and U3-K. The use of a double-V girth weld will be considered the equivalent of Fig. U3-J.

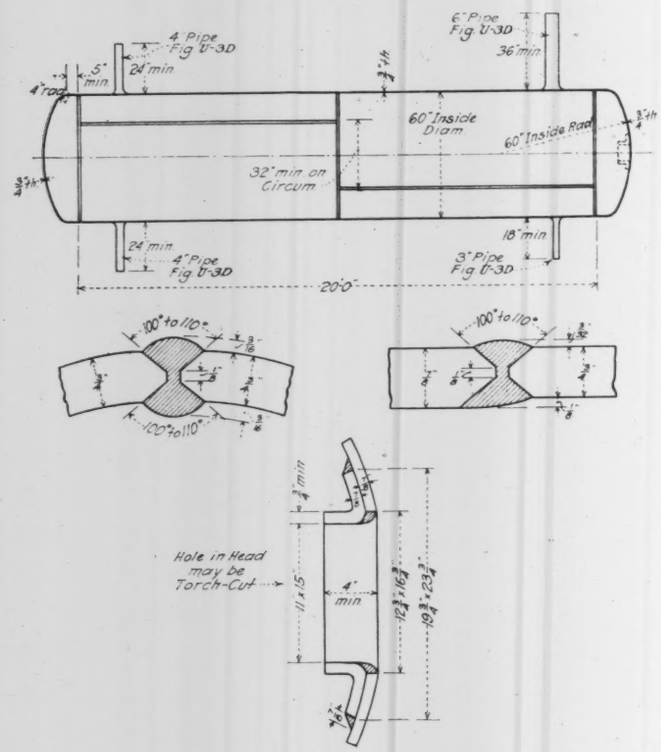

FIG. 9 PRESSURE VESSEL FOR A WORKING PRESSURE OF 200 LB. PER SQ. IN.

The calculated strength of the construction in Fig. 6 shall be such that the strength of the outside fillet weld and the sum of the spot or tack welds shall each be equal to at least 3000 lb. per sq. in. of cross-section of the shell.

NOTE: The greatest objection to the usual design of welded ~~convex~~ concave inserted head is that it is not possible to prevent some bending stress on the weld, because of the distortion of the head under pressure and because a perfect fit cannot be had between the head and the shell The design using spot or tack welds at the end of the flange as shown in this code avoids this bending and so makes a safe construction, which should be allowed.

The calculated strength of each part of the weld is $37^1/_2$ per cent of 8000 lb., a total of 75 per cent, rather more than the theoretical 50 per cent ratio of the strength of a girth section to a longitudinal one.

The design also provides for omission of the theoretical corner strength of a perfect weld, as it is sometimes difficult to get these corners thoroughly fused.

8 Nozzles in heads and shells shall not exceed 12 in. in nominal diameter. They shall be of forged or rolled steel, and shall be welded to the shell or head as shown in Fig. U3-A. The nominal diameter of the nozzle shall not exceed one-third of the shell diameter.

NOTE: This has been changed from Section U76 to make the nominal size limit clear. The ratio of diameters of the shell and nozzle should not be less than 3 to 1, in the author's opinion, in a pressure vessel. In piping the fiber stress is much less, and a smaller ratio, even 1 to 1, is permissible in many cases.

9 Threaded connections shall not exceed 12 in. in nominal diameter and shall be made as in Figs. U3-b to U3-i and Table 1. Flanges shall be of forged steel and shall fit closely to the plate before welding. Pipe nipples shall be of extra heavy pipe for a distance from the shell of at least 6 times their nominal diameter.

Where nipples are threaded into the plate without any welding, and the plate is too thin for the number of threads called for in Table U5 of the A.S.M.E. code, a boss may be built up by fusion welding to provide for such threads, if the nominal pipe size does not exceed 2 in. The nominal diameter of threaded connections shall not exceed one-third the nominal shell diameter.

TABLE 1 FLANGE, NOZZLE, AND PIPE CONNECTIONS

Figure	Shell thickness	Allowable working pressure	Shell diameter	Maximum nominal pipe size, in.
U3-A	any	any	any	12
U3-B	any	any	any	12
U3-C	any	any	any	3
U3-D	any	any	Any that can be welded inside.	8
U3-E	any	250	Any that cannot be welded inside	4
U3-F	any	150	any	2
U3-G	any	any	Any that can be welded inside	8
U3-H	any	100	any	2
U3-I	$^3/_{16}$ in. min.	any	16 in. min.	1
I	$^1/_4$ in. min.	any	30 in. min.	$1^1/_2$
I	$^3/_8$ in. min.	any	48 in. min.	$2^1/_2$

NOTE: Forged-steel flanges have been required, and the building up of a boss is copied from Section U59, for completeness, with the 100-lb. pressure limit omitted, as the author believes it to be entirely unnecessary.

Table 1 is copied from Bulletin No. 5. The author believes it to be more rational than the limits in Fig. U3, because it takes account of practical conditions and welding possibilities, as well as giving more scope in the application of nipples in perfectly safe ways.

10 Each tank shall be tested under hydrostatic pressure to $1^1/_2$ times its maximum allowable working pressure, care being taken to remove all air from the tank and its connections. While under this pressure, it shall be struck swinging blows at intervals of 6 in. along all seams with a hammer of from 2 lb. weight for $^1/_8$-in. shells to 12 lb. for $^3/_4$-in. shells, the hammer being allowed to fall freely from full arm length but with only the force of its own weight.

After this test the pressure shall be raised to 3 times the maximum working pressure and be held there 3 minutes.

NOTE: The above test that recommended by the A.W.S. in Bulletin No. 5, and is practically the same wording as U78, the changes being with the idea of making the test more easy of interpretation and execution.

It is impossible to discuss it fully here. Bulletin No. 5 devotes 3 pages in the Bureau of Standards report, and 6 pages in the committee report to it.

In general it was shown that even a permanent distortion of a tank by the hydrostatic test seems to have no detrimental effect on the strength of a properly welded tank, and that the hammer test does detect some defects that otherwise would be missed.

The results do not show that this test will invariably detect a tank that the author thinks should be rejected, and even a test pressure of 4 times the working pressure would not accomplish this.

No one has yet defined a bad weld, and so it is not possible to agree on how far a test should go. But it is sure that a double-V weld is good, and as Bulletin No. 5 shows that it is in all cases thoroughly reliable, and as no double-V weld has ever failed, let us spend our time in making and improving what we know to be good, and then we need not worry about bad welds and how to find them, for there will be none.

OMISSION OF SOME PARTS OF THE A.S.M.E. CODE FROM PROPOSED FUSION-WELDING CODE

It will be in order to explain why many of the A.S.M.E. code provisions are omitted in this proposed code.

Section U17, giving the minimum allowable thickness of shell for given diameters, corresponds to similar provisions in other A.S.M.E. codes. (See section P17 of the Power Code, and Section H12 of the Heating Code.) In U17, the author believes the thickness of the smaller diameters was designed to allow for some corrosion. This is a matter that does not belong in a code, as corro-

sion is different in different places, and is therefore a matter for local decision and enforcement. Section U11 provides a general increase in thickness for corrosive contents, and Sections U53, U54, and U62 refer to means for internal inspection. If these provisions are followed there is no need for additional allowance in the thickness requirements, which should be based, as in other codes, on the allowable distortion due to the weight of the tank, or similar considerations, so that the inherent advantage of welded thin shells over riveted ones may be available.

It is hard for one not used to welding possibilities to visualize that a tank 16 in. in diameter and No. 10 gage in thickness required a pressure of 990 lb. per sq. in. to burst it, but Bulletin No. 5 shows it to be a fact.

The author has omitted any minimum limits for thickness and has depended on the provisions of Section U60, which says that supports must be such as to distribute properly the stresses due to the weight of the tank and its contents, adding that in no case should the stress on any part of the tank be increased more than 500 lb. per sq. in. of plate by the weight of tank and contents, or attachments to the tank, over the maximum allowable fiber stresses due to pressure. This insures proper design of the supports. The third sentence of this section is not applicable to welded vessels as it refers to riveted construction only.

Section U23 contains the following provisions for fusion-welded vessels: Longitudinal welded seams shall be used only for air vessels and then the diameter cannot be over 20 in., the length over 3 times the diameter, or the pressure over 100 lb. per sq. in. Circumferential welds are limited to tanks 48 in. in diameter unless the heads are flat and 75 per cent of the load is supported by stays, when the diameter may be 72 in.

There is no sound engineering reason for any of these restrictions, and therefore they have been omitted. The tanks in Bulletin No. 5 were 24 in. in diameter and $^3/_8$ in. thick, and many of them stood 1600 lb. without leaking before rupture. This alone is sufficient to show that the code limitations are unreasonable. There is plenty more evidence to confirm this.

It is also evident that if it is safe to weld material $^5/_8$ in. thick, which is permitted by the code in Section U70, and if a fiber stress of 8000 lb. is safe, as shown by Bulletin No. 5, there is no need for any other restrictions, as these two automatically decide the diameter and pressure. The author knows that it is perfectly safe to weld material $^3/_4$ in. thick, and as tanks of this thickness have been made, tested in accordance with the code, and proved satisfactory in service, this thickness has been allowed. There is no reason why greater thicknesses cannot be welded. In fact, $1^1/_2$-in. and 2-in. plates have been successfully welded, breaking at over 60,000 lb. per sq. in. of plate or else, with lower-strength plate, outside the weld.

Therefore the $^3/_{16}$-in. thickness limit imposed by the code for longitudinal seams is uncalled for, and has been omitted.

There is no reason for limiting the diameter of welded vessels that would not apply equally to vessels with other types of joints. A weld is equally safe in $^3/_{16}$-in. plate whether the diameter is 20 in. or 20 ft. If the volume of a large vessel is objectionable, either apply efficient and sufficient safety devices, or make the restrictions apply to all vessels. Other procedure than this is not based either on logic or engineering. The restriction applies only to fusion-welded vessels, and so has been omitted.

The length of longitudinal seams is limited to 3 times the diameter. There is no good reason the author knows of for this, there being no relation between diameter and length that influences the strength unless the tank be very short; and as in Bulletin No. 5 the test results show that the bursting fiber stress was practically equal to the ultimate strength of the plate, and as these tanks were not over 3 times their diameter, it is clear that with this ratio any influence of the heads is absent just as much as it would be in longer tanks, so there is no point in limiting the total tank length unless a much smaller ratio than 3 to 1 be adopted.

However, there is a practical reason for limiting the length of any course, which lies in the difficulty of welding the inside of a seam when the tank is long and of small diameter.

However, as it is not a matter on which strength depends, it has been entirely omitted from the code, and left to the manufacturer to work out.

The limit of 100 lb. pressure is not reasonable because there is no greater stress on a weld in a 10-in. shell at 200 lb. pressure than in one 20 in. in diameter at 100 lb., and because fiber stress is what governs the strength, not pressure. Also as the maximum fiber stress and maximum thickness are specified, this restriction has been omitted.

Nor is the restriction of longitudinal seams to air vessels based on any engineering reason. Content has no bearing on design, if the pressure exerted by the content be known. If it be not known, it must be determined before a design can be made. Excess pressure is always taken care of by safety valves or similar devices, and never by making a tank heavy enough to stand any possible pressure that might be generated in it. Also for a given pressure the fiber stress is the same for any content, and if the latter be dangerous, the local authorities should see that enough efficient safety devices are applied to remove the danger. This is not a function of the code, because it is impossible for it to provide for all possible conditions. The general principles given in the A.S.M.E. code, in Sections U2 and U10, go about as far as is possible in regard to safety devices.

The restriction of contents to air has therefore been omitted.

Section U74 refers to convex heads, but its meaning is not at all clear as to the desired construction, though this could be easily remedied. But the requirement that the shell end shall be constricted is an entirely unnecessary burden, because there is no evidence that it adds to the strength. On the contrary, the treatment needed to do the crimping may cause injury to the weld. It is further evident that unless there is an exact fit between the head and shell the stress is on the weld in any case, it being in shear up to the yield point. Professor Roark gives a very good analysis of the stresses in this form of joint, in the paper referred to.

There may be no objection to an engineer specifying such a construction, but it should not be mandatory and therefore has been omitted from the code.

Section U79 provides that defective sections of a weld may be repaired provided the value of the sheet has not been definitely lowered. This is impossible of enforcement, because there is no way of determining the value of the sheet. The requirement should be omitted. The entire section has been omitted as it is unnecessary.

SPECIFICATION FOR A FUSION-WELDED TANK 60 IN. IN DIAMETER, 20 FT. LONG, FOR A WORKING PRESSURE OF 200 LB. PER SQ. IN.

1 The tank shall be made in accordance with these specifications and the drawings attached thereto, and in accordance with the laws of the state and municipality in which it is to be operated. Unless otherwise specified it shall conform to the attached code for unfired pressure vessels.

2 The plate shall be of firebox quality made by the open-hearth process, and shall be of the following chemical composition:

Carbon	0.15 per cent max.
Manganese	0.30 per cent to 0 60 per cent
Phosphorus, not over	0.05 per cent
Sulphur, not over	0.05 per cent

It shall have a maximum tensile strength of 56,000 lb. per sq. in.

With these exceptions it shall conform to Sections S5 to S17 of the A.S.M.E. Power Boiler Code, and to the weight requirements of A.S.M.E. Spec. A70-24.

3 The welds shall be made by the oxyacetylene welding process.

4 All bevels shall be made by machining where possible. If it is necessary to trim or bevel plates with a cutting torch, all scale shall be removed down to clean metal. All surfaces to be welded shall be thoroughly cleaned before welding.

5 The welding rod shall be nickel steel to meet A.W.S. specifications, or of such other composition as will give practically equal weld stength and ductility, and that will meet the engineer's approval. The use of ordinary low-carbon-steel rod will not be permitted.

6 If approved by the engineer, the contractor may increase the number of girth seams to suit the size of sheets obtainable.

7 The length and radius of fillet welds shall conform to the note to Fig. U3 of the code.

8 In case a weld is found defective at any time during the test, it may be repaired as follows:

Pinholes shall not be calked, but may be welded up if the surrounding metal is properly preheated.

If a crack of any length appears in the welds at any time during the construction or test of the tank, it may be rewelded provided that it is not more than 3 in. long, that there is not more than one to each 6 ft. of seam, that the weld metal along the crack is entirely removed, and that the surrounding metal is properly preheated. A general sweating of the weld under test may be repaired only by entire rebuilding of the vessel after all the weld metal has been entirely removed.

After repairs have been made, the vessel shall again be tested.

Rewelding may be done only once. Failure to pass the second test shall reject the tank.

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Labor Saving in Tunneling

AMERICAN distaste for back-breaking labor has led to many inventions. Tunneling for centuries was laborious, dangerous, uninviting. Only crudest methods and tools were employed until power drills and explosives were used in rock, and power-driven shields in soft ground. Explosives have been made safer and more powerful. Compressed air has been introduced to exclude water which would otherwise come in through the interstices of the ground. Metal and masonry tunnel linings have been improved and machinery invented for placing them. With engines and boilers came steam drills, then drills driven by compressed air, and finally electric drills. Compressed-air drills, however, do most of the tunneling today. Tunnels are now ventilated by power-driven fans and blowers. Electricity has made good lighting possible. Electric and compressed-air locomotives have supplanted the patient mule and the push-man. Surveying instruments and methods, too, have advanced remarkably. Tunnels can now be driven for long distances from portals or shafts, on straight lines or curves, or with angles, and the "headings" will meet exactly. Consequently, tunneling has become much more expeditious and economical, making feasible great improvements in alignment and grade of railways, highways, and aqueducts. For great waterway crossings, tunnels have been preferred to bridges.[1]

In rock tunneling, holes 2 to 3 in. in diameter are first drilled in suitable number and directions then, in proper sequence, loaded with explosives and "shot." The rock is broken out and thrown in a pile of fragments and dust just where the drillers must stand to begin the next "round."

Drills, although much lighter than a few years ago, still are heavy. They have to be mounted on heavy steel columns, bars, or tripods. After the holes have been drilled, the machines have to be dragged out of range of damage. Then as soon as enough of the "muck" has been cleared away, the drilling equipment has to be lugged back over the muck and set up—back-breaking work, falling upon the drillers. It has been difficult to get and keep good men. Intelligent Americans avoid such work. Mucking is hard work, too. The smaller debris is shoveled by hand and the larger chunks lifted by men into small cars.

The rate at which broken rock at a heading could be loaded into cars has heretofore been the limiting factor in tunneling. Where speed was desirable and hand mucking was employed, it was common practice to level the top of the muck, mount the drills on a crossbar and drill the holes in the upper half of the face while standing on the muck. By the time this was done, the muck would be so nearly cleared that the drills could be taken down and the remaining muck thrown back so that drilling could be begun on the lower half, either by lowering the crossbar or putting up columns.

With mechanical muckers reducing at least 60 per cent the time to clear the muck, when the drills were ready to begin operation, the mucking machine would be removing the muck on which the drillers were standing. Therefore, it was economy not to begin drilling until the muck was entirely cleared, when it was possible to lay track up to the face and thus avoid carrying the drills into the heading and setting them up by hand. The drills are now permanently mounted on a heavy car, which also carries the manifold air and water pipes for each drill, and can be pushed into the face by an electric locomotive, clamped into position and drilling commenced in from fifteen to eighteen minutes.

This, however, is not the sum total of advantages. Under the old system the drillers were usually tired before they began drilling. Under the new system the men begin drilling while they are still fresh, take greater interest in that work and make better speed. While men had to do such back-breaking work, when they accumulated a few hundred dollars, they quit the job. With introduction of mucking machine and drill car the men were no longer forced to do hard manual labor, but had merely to look after and operate machines. To most men, especially Americans, this is a congenial occupation. Hence, "turnover" has almost disappeared. As the men remain for longer periods, they become more expert. The net result has been greatly to cheapen and expedite the work. Thus has a new invention improved a whole chain of interlocking operations in tunneling through rock. (From information contributed by D. W. Brunton, Member American Institute of Mining and Metallurgical Engineers, Consulting Engineer, Moffat Tunnel, in Popular Research Narratives, vol. 6, no. 2, Feb. 1, 1926.)

[1] See Research Narratives Numbers 31 and 59; also "Mechanical Underground Loading in Metal Mines" by C. E. Van Barneveld, U. S. Bureau of Mines: published by School of Mines and Metallurgy, University of Missouri, Rolla, Missouri, 1924.

A Machine for Testing Steam-Turbine Nozzles by the Reaction Method

By G. B. WARREN,[1] and J. H. KEENAN,[2] SCHENECTADY, N. Y.

This paper explains in detail the apparatus used in reaction-nozzle tests, the important difficulties encountered, the means of eliminating them, and the methods of obtaining and developing test data. It discusses the underlying principles and the type of results they would indicate, and shows by sample test curves the close agreement between the expected and the actual data.

SOME years ago the General Electric Co. undertook the development of apparatus for finding the relative efficiencies of various types of nozzles and the absolute values of the losses in those nozzles. Investigations using this equipment have been made continuously since that time. They have supplied a great deal of information which has been utilized wherever possible in the design of the nozzles used in steam turbines built by the General Electric Co., and have provided data which have been valuable in the analysis of results obtained from tests of the turbine as a whole.

A part of this development followed the type of investigation outlined by H. Loring Wirt,[3] in which nozzles were tested with air, and another part took the form of the development and operation of a reaction-nozzle testing machine. These two investigations

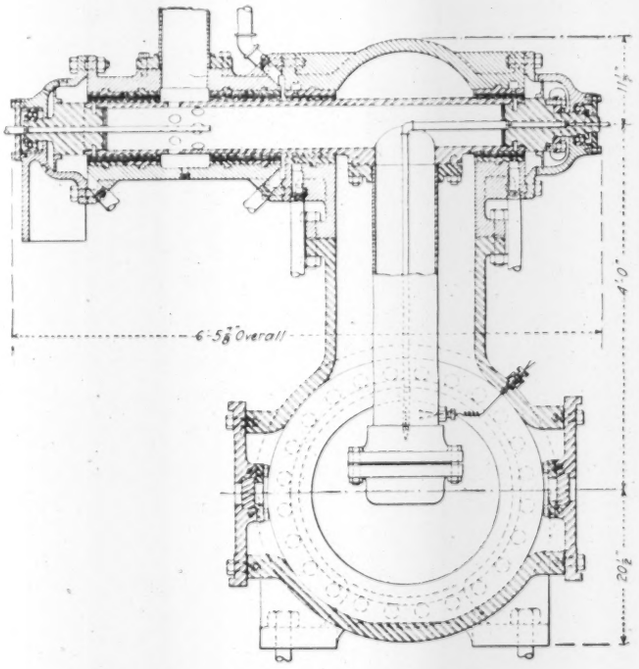

FIG. 1 NOZZLE-TESTING MACHINE—END ELEVATION

were carried on together; the reaction-nozzle tests giving the absolute values of the nozzle efficiency throughout a large range of pressures, velocities, superheats, and nozzle forms, while the air test permitted, as described in Mr. Wirt's paper, an analysis of the component losses and the extension of the investigation to the latter-stage nozzles, which were too large for testing in the reaction machine.

An extensive series of tests have also been made, and are still in progress, in which nozzles of various designs have been tested with bucket wheels in a steam turbine under actual operating conditions. In some cases direct comparative turbine tests have been made on nozzles tested by the air and reaction methods. In general these tests have borne out the conclusions obtained from the nozzle tests, but since so many other variables are necessarily involved when moving buckets are used, definite comparisons are somewhat complicated, and a discussion of these tests need not be given at this time.

This paper explains in detail the apparatus used in the reaction-nozzle tests, the important difficulties encountered, the means of

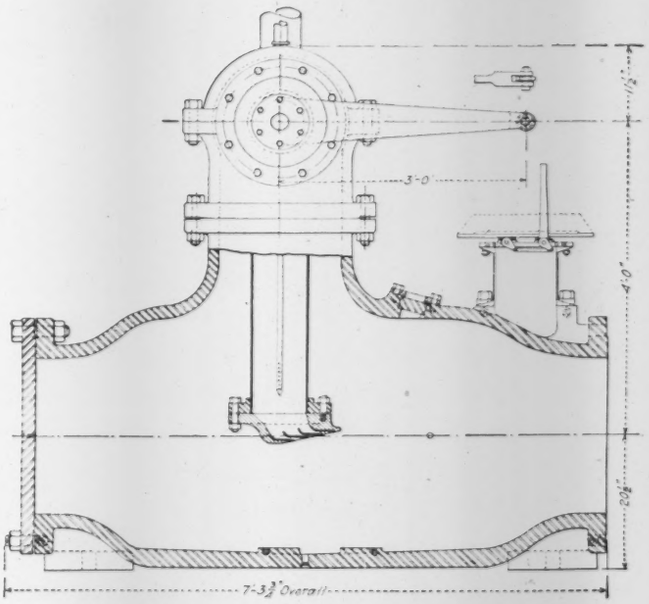

FIG. 1 NOZZLE-TESTING MACHINE—SIDE ELEVATION

eliminating them, and the methods of obtaining and developing test data. It discusses the underlying principles and the type of results they would indicate, and shows by sample test curves the close agreement between the expected and the actual data.

THE TESTING APPARATUS AND ITS OPERATION

Briefly, it may be said that the average velocity of a jet leaving a nozzle is equal to the ratio of the reaction of the jet to the mass flow per unit time. The average velocity when compared with the corresponding velocity which would be obtained from frictionless adiabatic expansion from the conditions ahead of the nozzle to the pressure after it, gives a measure of the nozzle performance.

The nozzle-testing apparatus here described is simply a device for measuring the flow through a sample nozzle, the steam conditions before and after it, and the reaction of the issuing jet.

General Description. The nozzle-testing machine and its auxiliary apparatus are shown in Figs. 1 to 3. From these it will be seen that the nozzle group to be tested is bolted to the bottom flange of a vertical pipe in such a way as to cause the nozzle to discharge horizontally. This vertical pipe is hung from a hollow horizontal shaft, with which it forms a vertical T. The shaft is supported at each end on ball bearings. The moment about the bearing axis of the reaction force at the nozzle is transmitted through a horizontal arm on the shaft to sensitive platform scales.[4]

[1] General Electric Co. Jun. Mem. A.S.M.E.

[2] General Electric Co.

[3] An Experimental Investigation of Nozzle Efficiency. Trans. A.S.M.E., vol. 46 (1924), p. 981.

Presented at the Midwest Power Conference, Chicago, Ill., January 26 to 29, 1926, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York. Abridged.

[4] The general design of this machine follows to a large extent that used by Dr. Paul Christlein for similar tests made at the Technical High School in Charlottenburg, during the years 1909 to 1911. [This work was reported in the *Zeitschrift für das Gesamte Turbinenwesen*, vol. 9 (1912).] However, the machine here described is considerably larger than Dr. Christlein's and embodies many refinements and modifications which should make for increased accuracy and ease of manipulation.

The exhaust-chamber shell extends up to and envelops the shaft. Steam is admitted at one end of the enveloping cylinder and it immediately enters the shaft through radial holes. It flows down through the vertical pipe, through the nozzle, into the exhaust chamber, thence to a surface condenser.

From the hotwell of the condenser the condensate line leads through a pump to the weighing tanks where a quick-closing valve operated by a precision clock automatically times the weighing operation.

DETAILS OF MACHINE AND ITS OPERATION

Measurement of Reaction. In order that the friction in the reaction element will not introduce appreciable systematic errors,

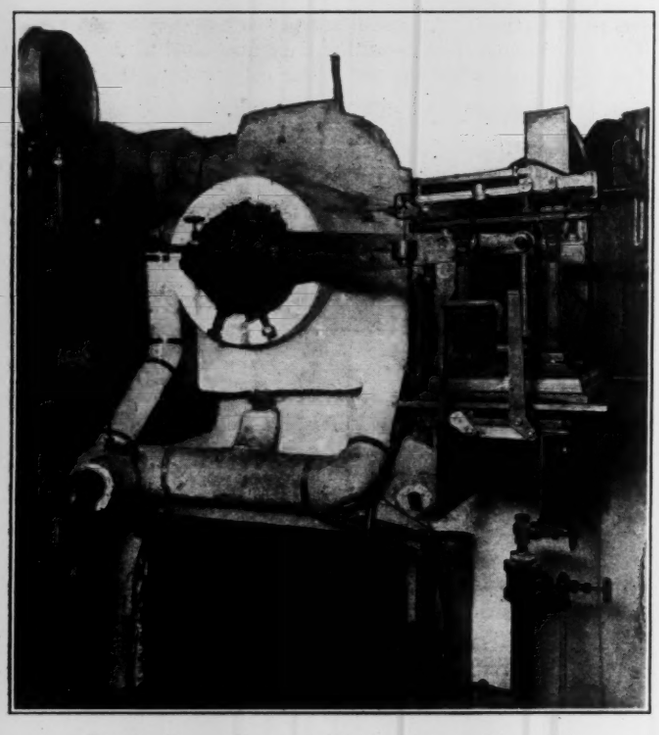

FIG. 2 FRONT VIEW OF NOZZLE-TESTING MACHINE
(Shows the reaction-measuring scales, the arm attached to the moving element, and the piping to the low-pressure packing.)

the reaction scales are mounted on cams which allow moving the scales up and down, which in turn moves the element back and forth through half a degree. When moved in one direction the friction acts *with* the reaction, when moved in the opposite direction it acts *against* the reaction. This method is used to obtain tare as well as gross reaction values, and the difference between the means of the two sets is practically free from friction effects.

Packings. It is, of course, extremely important to insure that all of the steam which passes through the nozzle reaches the condenser, and that no additional steam or water enters there without its quantity being known. The prevention of leakage into or out of the system is comparatively simple everywhere except in the condenser, as mentioned above, and at the shaft of the swinging element.

Along the length of the shaft at the inlet end of the machine steam must be prevented from leaking into the exhaust chamber. (See Figs. 1 to 3.) Two lengths of labyrinth packing (0.010 to 0.016 in. radial clearance) are provided on this section of the shaft. From the space between them sufficient steam is drawn off to an auxiliary condenser to maintain the static pressure in that space equal to the pressure in the exhaust chamber within a quarter of an inch of water. Special tests have shown that with the length of packing and the close clearances used the device is so effective that a pressure unbalance of several inches of water could exist without introducing appreciable error into the flow measurements.

The packing along the other end of the shaft is balanced in much the same way, except that here the pressure in the packing is kept slightly below atmospheric pressure so as to have a gentle flow of air inward. Since the steam drawn from the packing in this case has come from the exhaust chamber, it is necessary to lead it to the main condenser where it is mixed with the rest of the nozzle flow.

When the exhaust-chamber pressure is below atmospheric pressure it is necessary to bleed a small quantity of steam into this packing in order to maintain the condenser vacuum. The steam so introduced is first measured by means of a calibrated orifice, and the weighed flow is corrected accordingly.

The Main Condenser. Because of the uncertainty of condenser-leakage corrections, main condenser leakage is never tolerated. The condenser tubes are carefully packed and a test is made twice each day for leakage. This test consists of weighing the water pumped from the condenser under full vacuum when all steam inlets have been shut off. All flow must cease within 45 min. or the condenser is opened and inspected.

The air removed from the condenser while the machine is in operation is cooled below room temperature, and the condensed vapor is drained to the hotwell where it is mixed with the main condensate. (See Fig. 3.)

Pressure Measurements. Pressure measurements are made in all cases with mercury columns. The ordinary U-tube is used for pressures less than about 5 in. Hg. gage; above that the pressure is applied to a mercury surface in a reservoir whence the mercury is forced up into a long tube. Only a small correction for the change of level in the reservoir need be applied to the scale reading at the top of the column to obtain the column length. The pressure lines leading to the reservoir are filled with water to prevent condensation in them. Corrections must consequently be made for water columns as well as for the differential expansion between the mercury column and the scale with change in temperature.

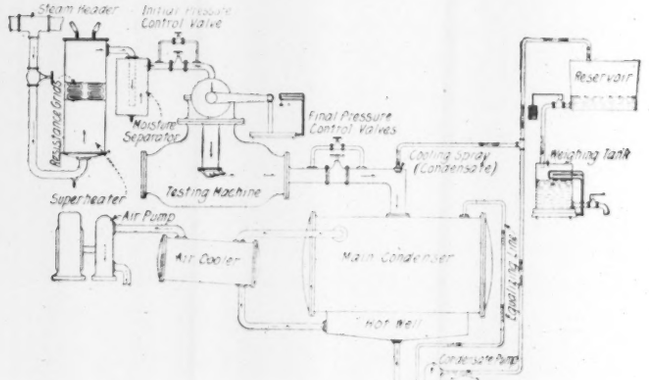

FIG. 3 DIAGRAM OF STEAM AND CONDENSATE SYSTEM OF NOZZLE-TESTING MACHINE

The initial pressure is obtained through sampling tubes whose walls are parallel to the stream flow; the final pressure through flush holes in the exhaust-chamber wall. Great pains were taken to insure quiet conditions in the exhaust chamber.

Two entirely separate measurements are made of both the initial and final pressures, and a direct measurement of the pressure differential across the nozzle is made whenever it is less than 50 in. Hg.

Temperature Measurements. The initial temperature is obtained by means of carefully calibrated base-metal thermocouples which project about two inches into the supply pipe immediately before the nozzle casting. The thermocouple cold ends are maintained at the freezing point of water, and the electromotive force generated is measured by a potentiometer.

Steam Supply. Steam is supplied to the machine from the power-plant steam header. On leaving the header it passes a group of moisture-injection nozzles, which may be used to lower its temperature, and then enters an upward-flow electric superheater which provides very sensitive control of the steam temperature, the heating grids being especially effective in breaking up and evaporating any drops of water. In addition, between the superheater and the testing machine the steam passes through a

moisture separator from the drains of which steam is always allowed to blow, thus doubly insuring dryness at the machine. Investigations from many points of view have given confidence that these precautions are effective.

THE POSITION OF THE NOZZLE DURING TEST

The nozzle casting is so made that when it is bolted to the flange on the approach pipe the plane of the tail portion of each nozzle partition is normal to the axis of the approach pipe. This means that when the nozzles are discharging parallel to those planes, the moment of the reaction about the bearing axis is the product of the jet reaction and the distance from that axis to the middle of the central nozzle passage.

This, of course, is no longer true once the jet deflects out of the plane of the partition tail. Above the sound velocity a downward deflection of the jet from non-diverged nozzles does occur, and its effect on the reaction measurement becomes of increasing importance as the velocity increases. However, the sound velocity must be exceeded by a considerable amount before the effect of jet deflection becomes appreciable, and in this region of high velocities the tests on non-diverged nozzles are of little practical significance.

Below the sound velocity there is a slight upward deflection of the jet which is caused by the filling of the space immediately following the exit edge. This deflection has been carefully investigated by means of air tests which have invariably indicated that for the thin-edged nozzles used in most of these tests the effect of the deflection alone on the measured reaction would be well within 0.3 per cent, and is probably nearer 0.1 per cent. This error is, however, practically counterbalanced, as explained later, by the moment about the bearing axis of the downward reaction component which slightly increases the measured reaction. The elimination of the small error involved would hardly justify complicating the test procedure by adjusting the nozzle position for jet angle.

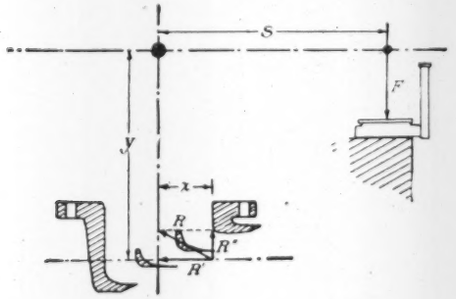

FIG. 4 DIAGRAM OF REACTION COMPONENTS AND THEIR MOMENT ARMS IN THE NOZZLE-TESTING MACHINE IN CASE OF A DOWNWARD DEFLECTION OF THE JET
(Testing machine in case of a downward deflection of the jet.)

METHOD OF TESTING

A single point on Fig. 9 or 10 represents a test of from one-half to one hour duration. The test is usually preceded by a period of 15 to 30 minutes' operation in order to bring the flow to an equilibrium value. During this entire time the initial pressure and temperature and the final pressure are held at the desired values. The reaction, the pressures and the initial temperature are read at three-minute intervals; the flow is measured at six-minute intervals. The deviations from each other of the five or more flow readings that are taken during a test must not exceed one per cent and are usually considerably less than one per cent. The averages of these readings taken during the test are then converted into the final form.

CALCULATIONS

The final form of the data obtained from the machine is the curve sheet of velocity and flow coefficients. (See Figs. 9 and 10.) The velocity coefficient may be defined as

$$C_v = V/V_0 \quad [1]$$

where V = actual velocity

V_0 = theoretical velocity.

The actual velocity is found from

$$V = Rg/Q \quad [2]$$

where R = reaction force at the nozzle, lb.
Q = flow in unit time, lb. per sec.
g = acceleration of gravity = 32.17 ft. per sec. per sec.

The flow coefficient is

$$c_q = Q/Q_0$$

where Q_0 = theoretical flow in unit time, lb. per sec.

The theoretical values are calculated from the Marks and Davis steam tables when the ratio of the final to the initial pressure is less than 0.85. When the pressure ratio exceeds 0.85 the energy drop becomes so small that the deviations in the values obtained from the steam table exceed the probable error of the test. It is then assumed that the adiabatic expansion is of the form

$$p(v - b)^k = \text{constant}$$

where p = pressure, abs.
v = specific volume
k = 1.3 for superheated steam
b = coaggregation volume = 0.016 cu. ft. per lb.

From this the theoretical velocity may be deduced:

$$V_0 = \sqrt{2gp_1(v_1 - b)\frac{k}{k-1}\left[1 - \left(\frac{p_2}{p_1}\right)^{\frac{k-1}{k}}\right]}$$

where p_1 = initial pressure, abs.
p_2 = final pressure, abs.
v_1 = initial specific volume and is found from the Marks and Davis steam tables.

THE EFFECT OF JET DEFLECTION ON TEST RESULTS

In this investigation the actual velocity is calculated from the formula

$$V_a = \frac{F}{Q} \times \frac{\text{(scale arm)}}{\text{(nozzle arm)}} \times \text{constant}$$

where F is the reaction indicated by the platform scale, "scale arm" is the distance from the axis of the bearings of the machine to the point where the force is applied to the scale, shown as s in Fig. 4, "nozzle arm" is the distance from the bearing axis to the horizontal center line of the nozzle passages, shown as y, and Q is the flow in lb. per hour. This formula gives the true value of V_a when $F \times \frac{\text{scale arm}}{\text{nozzle arm}}$ is equal to the resultant reaction of the jet R, which is the case only when the resultant reaction is perpendicular to the axis of the nozzle arm. In general, however, this is not the case for velocities greater than those corresponding to the characteristic pressure ratio of the nozzle, and it is not always true for velocities less than that value (for example, where deflection toward the tail piece occurs). When any deflection from the direction perpendicular to the nozzle arm occurs a reaction component R'' normal to that axis is set up, the resultant of which is applied at some distant x from the bearing axis. (Fig. 4.) The moment of this component, $R''x$, is then added algebraically to the moment of the axial component, $R'y$, to give the moment of the force applied to the scale, Fs.

When the deflection is downward the moment of the consequent normal component of the reaction would in the case of all the nozzles tested be opposite in sign to the moment of the axial component of the reaction. Hence in such a case

$$Fs < R'y$$

and

$$F\left(\frac{s}{y}\right) < R'$$

and the V_a calculated is less than the axial component of the true V_a. The measured velocity coefficient of an oblique-outlet nozzle above the characteristic velocity is consequently less than that of the corresponding normal-outlet nozzle, though as explained earlier

in the complete paper, in the true velocity coefficient of the oblique-outlet nozzle is the greater.

In the case of upward deflection of the jet the measured reaction would be slightly increased by the moment of the downward reaction component. But the horizontal reaction component decreases with the cosine of the angle of deflection as that angle increases, and consequently the moment $R'y$ decreases. There are two opposing effects here which are very small and of the same order of magnitude for the thin-edged nozzles that have been tested. For the nozzle shown in Fig. 10 these errors are balanced

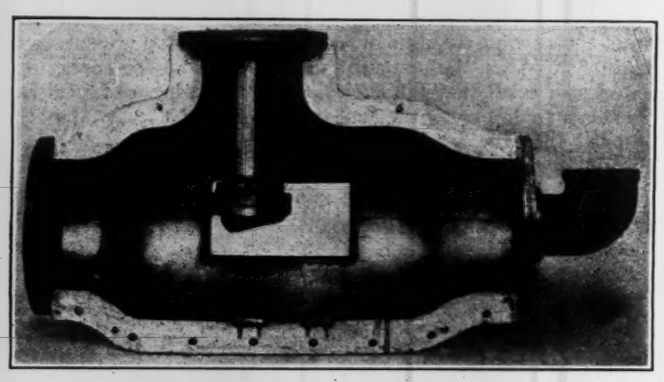

FIG. 5 QUARTER-SIZE MODEL OF EXHAUST CHAMBER, APPROACH PIPE, AND NOZZLE

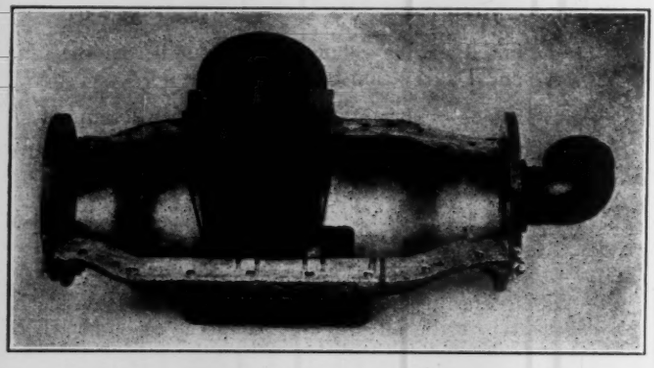

FIG. 6 MODEL OF EXHAUST CHAMBER WITH SHIELD IN PLACE

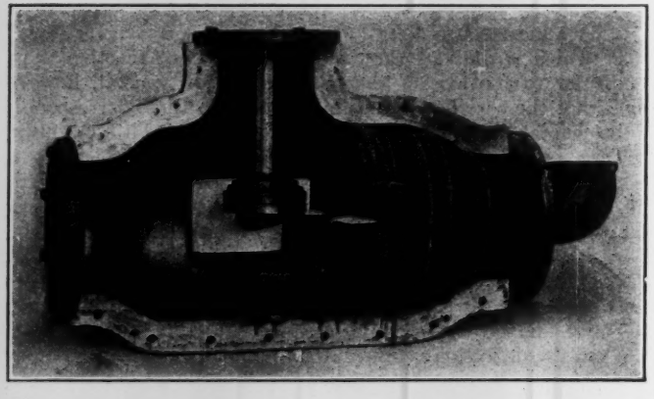

FIG. 7 MODEL OF EXHAUST CHAMBER WITH SCREENS INSTALLED
(Large-scale reproduction of the screens shown was used to eliminate circulation effects in the testing machine.)

for an upward deflection of about 3 deg. The probable value of the maximum upward deflection is about 1 deg., for which both these effects are negligible.

The effect of the upward component of the reaction on the measured reaction is very small for some distance above the sound velocity. It becomes, however, of increasing importance as the velocity increases.

In Fig. 10 the test curve is compared with the curve calculated from the linear pressure ratio-reaction relationship of the normal-outlet nozzle. The difference between the two curves is the effect of the upward-reaction component.

MEAN VELOCITIES

The mean velocity calculated from the reaction and flow measured by the testing machine is not the mean velocity over the cross-section of the jet. It is the velocity which that uniform jet would have whose mass flow and momentum in unit time were equal respectively to the mass flow and momentum in unit time of the actual jet. The square of the velocity coefficient would be the efficiency of this hypothetical jet. $^1/_2MV^2 \div {}^1/_2MV_0^2$.

Since a change from a non-uniform to a uniform velocity throughout a jet is an irreversible action, it follows from the second law of thermodynamics that such change is accompanied by a loss in kinetic energy. The momentum remains constant during such an equalization of the velocity, and so for jets of equal momentum, the one having the greatest variation of velocity across it would have the greatest kinetic energy. Since a nozzle jet is never uniform, it follows that the efficiency will always be somewhat higher than the square of the reaction velocity coefficient. The difference, with the amount of non-uniformity which exists in the case of the flow of superheated steam through a turbine nozzle, is, however, only a fraction of one per cent. If no moisture is present in the jet, it is probably well within 0.1 per cent for the nozzle shown in Fig. 10.

DISCUSSION OF THE EARLY RESULTS OBTAINED AND THE INVESTIGATION OF EXHAUST-CHAMBER CIRCULATION

The first consistent data obtained from this machine indicated a velocity-coefficient curve which had an upward trend with increasing velocity and exhibited a peak at a velocity 50 per cent in excess of the sound velocity. (See Fig. 8.) All the known factors served to indicate that the curve for a non-expanding nozzle should reach a maximum shortly after passing the sound velocity, and that when a velocity of 50 per cent in excess of the sound velocity is reached, it should be experiencing a rather rapid decline.

Explanations of the observed data were diligently but vainly sought, until it was recognized that there was a possibility of error in the reaction measurements resulting from circulation of the steam in the exhaust chamber. The impact of a circulating stream on one side of the nozzle approach pipe accompanied by an evacuation of the space on its opposite side would add a positive or negative increment to the jet reaction. Consequently a shield was built about the reaction element as shown in Fig. 6.

The first test made on a non-diverged oblique nozzle subsequent to the installation of the shield showed a curve which had no high velocity peak and which behaved much as expected above the velocity of sound. Below the velocity of sound it had lost most of its slope downward with decreasing velocity, but it had acquired a curl upward which began at a little less than one-half the sound velocity and was still in progress at the lowest velocity investigated.

There were many reasons for entertaining suspicions concerning the validity of this low rise in velocity coefficient. A few of them are enumerated.

1 All investigations of friction losses of the nature of those found in turbine nozzles have indicated an increase in the ratio of the energy loss to the kinetic energy supplied, or else a constant value of that ratio as the velocity decreased. Among them may be mentioned the National Physical Laboratory pipe-friction experiments,[5] the investigations of the resistance offered to flow of air past spheres,[6] cylinders,[7] and airplane struts,[8] and the various investigations of the friction of fluids on flat plates.[9] The National Physical Laboratory experiments did show a sharp drop in the loss ratio at the change from turbulent to streamline flow, but a very

[5] *Phil. Trans. A*, vol. 214 (1914), p. 199.
[6] C. Wieselsbeiger, *Physikalische Zeitschrift*, vol. 22 (1921), p. 321.
[7] *Ibid.*, vol. 23 (1922), p. 219.
[8] Applied Aerodynamics, Bairstow. Longmans, Green & Co., 1920, p. 392.
[9] Froude, Report of Brit. Assoc. Adv. of Sc., 1872, p. 118, 1874, p. 249.
Zahm, *Phil. Mag.*, vol. 8 (1904), p. 58.
Thurston, *Engrg.*, vol. 95, Jan. 24, 1913, p. 107.

smooth and undisturbed flow was necessary to obtain this discontinuity—a condition which could hardly exist in the sharp turn at relatively high velocities in a turbine nozzle.

2 Tests of various kinds have been made on exit-edge losses and vena contracta losses, and though they are not all in good agreement, none have indicated that these losses varied in a manner which would explain a velocity-coefficient curve of the type that was being obtained.

3 Occasionally when sufficiently low velocities were reached, the velocity coefficients attained the alarming magnitudes of 101 and 102 per cent.

TESTS ON MODEL OF EXHAUST CHAMBER

In order thoroughly to investigate the circulations in the exhaust chamber, a model of it was built (see Fig. 5) and tested with air. The tests made on the model proved to be extremely valuable. The information which they yielded concerning the apparatus as used before the model tests may be briefly summarized as follows:

1 High-velocity circulations, reaching 400 ft. per sec. at times, existed in the exhaust chamber.

2 The circulation was caused by splashing of the stream on the end flange of the exhaust chamber and flow backward out of the incompletely filled exhaust pipe.

3 A part of the nozzle stream was striking inside the front face of the shield, and probably was being reflected back against the

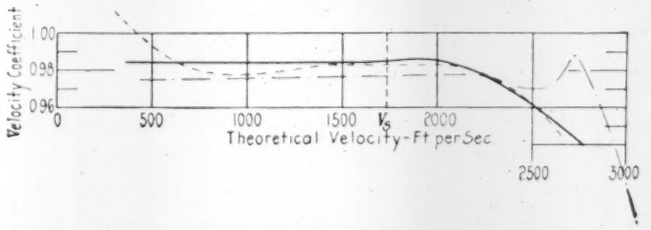

FIG. 8 TEST RESULTS OBTAINED FROM TURBINE NOZZLE SHOWN ON FIG. 10

(The dot-and-dash curve was obtained before provision was made to eliminate the effect of circulation in the exhaust chamber. The dash curve was obtained with a shield installed (as in Fig. 6). The solid curve is from the final test made after the exhaust-chamber circulation had been eliminated. The velocity of sound is indicated as V_s.)

nozzle pipe. This was, doubtlessly, the explanation of the low rise in velocity coefficient, since all jet-angle investigations have indicated a decrease in jet angle with a decrease in velocity.

Various attempts were made in the model machine to eliminate the circulation or its effect. The method finally adopted for use in the testing machine was that shown in Fig. 7. It is simply a device which allows most of the jet easily to reach the exhaust pipe, while it destroys the kinetic energy of any parts of the jet that might be deflected toward the nozzle. It consists of a series of coarse screen disks, with small central holes, set parallel to each other in that part of the chamber between the nozzle and the exhaust pipe. An annulus of fine screen is secured to each disk, concentric with it, and fitted closely to the chamber wall. A few half-disks of the same design were placed on the nozzle side of the series at the bottom of the chamber to prevent reflection of the deflected jet at high velocities.

This device was so effective that when installed a match flame would live where velocities of 300 ft. per sec. had existed in the unscreened chamber. A water manometer would indicate no differences in static pressure throughout that part of the chamber not occupied by the screens.

The "screen pad" appeared to be the solution of the problem. It was manufactured to the larger scale and installed in the testing machine. In order to determine whether the large-scale reproduction of the screens was as effective as the screens in the model, two types of investigations were made.

The first was a series of tests on a nozzle with the screen pad in place, followed by similar tests with a close-fitting shield about the nozzle pipe which would as nearly as possible shelter it from all circulation streams. Regardless of whether or not the shield was in itself a perfectly efficient device, any circulation effect in the absence of the shield would be evidenced by a change in the reaction when the shield was installed. A comparison of the reactions as determined by the two series of tests follows:

MEASURED REACTIONS WITH SCREEN PAD

Pressure ratio	Without shield	With shield
0.3225	85.45	85.43
0.3208	85.57	85.69
0.6435	53.13	53.18
0.6430	53.17	53.20
0.8612	23.34	23.43
0.8606	23.40	23.26
0.9138	14.83	14.88
0.9136	14.87	14.81

A second type of investigation consisted of determining the reaction for a given nozzle with atmospheric back pressure, then removing the back plate of the exhaust chamber and once more reading the reaction as well as noting carefully the lack of uniformity or the disturbances in the outward drift of the steam. The reaction comparisons for two different nozzles follow:

	Test No. 1	Test No. 2
Theoretical jet velocity, ft. per sec.	1770	2480
Flow through nozzle, lb. per hr.	6400	3500
Measured reaction with closed chamber, lb.	177.73	141.57
Measured reaction with open chamber, lb.	177.95	141.66

The slight rise in the reaction when the plate is removed may be accounted for by the outward drift of the steam impinging on the nozzle pipe. This outward drift was gentle and uniform at any elevation. It decreased toward the bottom where it became an inward drift of air—the normal convection type of circulation. The inward drift destroying the condenser vacuum forced a large amount of the steam out through the open end of the chamber, thus increasing the outward drift. An impact tube was used to measure the drift velocity, the exploration being made into the chamber as far as the nozzle, and nowhere did it indicate an impact pressure greater than 0.02 in. of water, though the steam issued from the nozzle at 1770 ft. per sec. in one case and 2480 ft. per sec. in the other.

THE CONDITIONS OF APPROACH

The conditions in the approach pipe have not been a source of trouble, as were the conditions in the exhaust chamber. However, they have been subject to careful tests to determine whether the kinetic energy of the steam before entering the nozzle was small enough to be negligible. This would be true in the case of practically all the tests made, provided there was a uniform velocity distribution in the approach pipe. If, however, a high downward velocity existed in the center of the pipe with low downward or upward velocities at the sides, then the kinetic energy of approach would be an unknown, though appreciable, increment on the available energy.

A test was made on a high-flow nozzle with the ordinary approach conditions. Following this a test was made on the same nozzle with the approach conditions so adjusted as to give uniform distribution. The uniform distribution was obtained by inserting in the approach pipe several groups of orifices in series, followed by baffles and screens which redistributed the flow over the entire pipe cross-section. This device was thoroughly tested with air before being installed.

If non-uniform distribution had introduced error in the tests without baffles, it would be such as to raise the available energy and hence the observed velocity coefficient above the true value. However, these tests made without the baffles gave an average velocity coefficient slightly lower, less than 0.25 per cent, than the tests made with uniform distribution, a difference within the range of testing error.

These results were obtained with a volume flow ahead of the nozzle which has seldom been exceeded. In other words they offer especial proof of the uniformity of flow to the nozzle in all cases.

THE FINAL RESULTS

The apparatus, embodying all the improvements and devices developed to eliminate the difficulties just discussed as well as others much more numerous, though of lesser importance, is in constant use for the analysis of nozzles used in turbine manufacture. A large variety of types have been tested. The coefficients

obtained from a test of an elementary nozzle are shown in Fig. 9 and those obtained from a test of a sample turbine nozzle in Fig. 10.

In these results one of the outstanding features is the high velocity coefficients shown by both the elementary nozzle and the turbine nozzle. The painstaking investigation and study involved in the development of this machine to its present state would justify confidence in the absolute results it indicates. However, a further check was available in the impact-tube air test described in Mr. Wirt's paper.[10] The turbine nozzle shown in Fig. 10 was

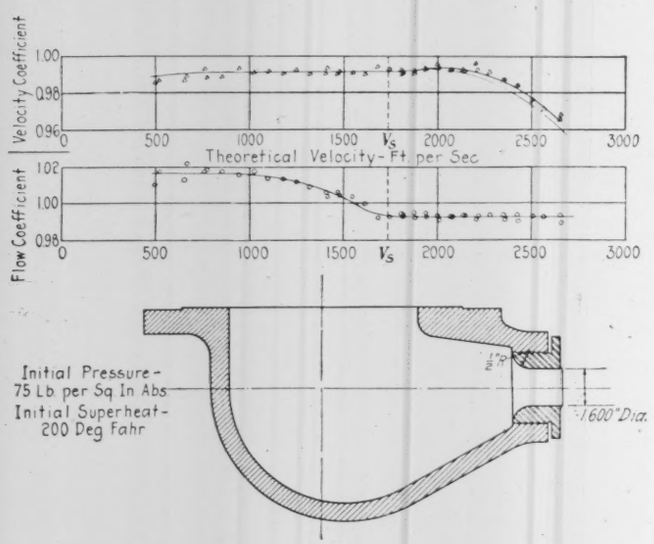

FIG. 9 TEST RESULTS ON A NORMAL-OUTLET CONVERGING NOZZLE

(The sound velocity is indicated as V_s. The velocity-coefficient curve calculated from the straight-line pressure ratio-reaction relationship is shown as a dot-and-dash line.)

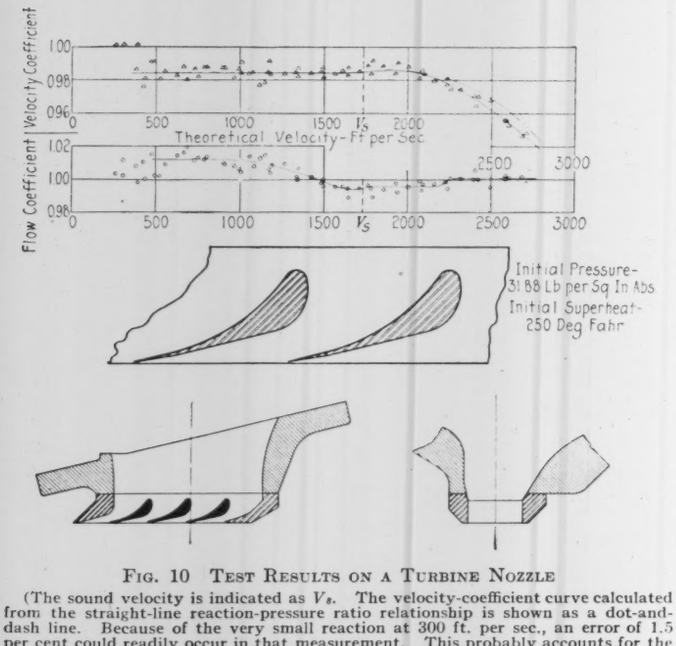

FIG. 10 TEST RESULTS ON A TURBINE NOZZLE

(The sound velocity is indicated as V_s. The velocity-coefficient curve calculated from the straight-line reaction-pressure ratio relationship is shown as a dot-and-dash line. Because of the very small reaction at 300 ft. per sec., an error of 1.5 per cent could readily occur in that measurement. This probably accounts for the high velocity-coefficient points at that velocity.)

carefully tested by the impact-tube method and the values obtained are compared below with the corresponding values obtained from the steam reaction test.

Ratio of theoretical velocity to sound velocity	Efficiency C_v^2, per cent — Reaction test, steam	Impact test, air
0.86	96.8	97.1
0.67	96.8	96.3
0.50	97.4	97.5

The differences between the two sets of data are well within the probable error of the impact-tube method.

[10] Trans. A.S.M.E., vol. 46 (1924), p. 981.

Another feature of interest is the constant velocity coefficient shown by both the elementary nozzle and the turbine nozzle for all velocities below the velocity of sound. This characteristic is checked satisfactorily by the air-test data given above and has been further verified by a series of impact traverses taken at different velocities along the center line of similar nozzle groups.

A constant velocity coefficient means constant efficiency, which in turn means that the friction forces involved are proportional to the square of the velocity. This is in agreement with nearly all the existing higher velocity tests on the resistance to flow of a fluid past flat plates, spheres, cylinders, airplane struts, etc.

Above the velocity of sound the test curves shown are compared with the values calculated from purely theoretical considerations. For the elementary nozzle the test curve and the calculated curve almost superimpose, while for the turbine nozzle the slight disagreement is a further justification of the results.

The experience acquired in five years of almost continuous operation of this machine impresses one with the difficulties involved in the development of an apparatus of its kind which will give not only the relative efficiencies of several nozzles, but dependable absolute efficiencies as well. It also impresses one with the unwisdom of making a statement to the effect that systematic errors no longer lurk within the apparatus. But a belief that any such errors that do still exist are of minor importance is justified by the experience acquired, the many difficulties overcome, and the agreement of the results throughout with logical considerations.

Personnel Research Federation

BELIEVING that there is a "human element" in all kinds of engineering, Engineering Foundation joined about five years ago with the National Research Council and other bodies in organizing Personnel Research Federation.

Since 1921, Personnel Research Federation has been exploring and developing its province, gaining support and promoting a number of researches. Since 1922, it has issued the *Journal of Personnel Research*, which has become recognized as a unique and useful publication in America and other countries. In 1925, the Federation was incorporated under the laws of New York and established offices at 40 West 40th Street, New York City.

Dr. Walter V. Bingham, formerly Director, Division of Coöperative Research, Carnegie Institute of Technology, Pittsburgh, was engaged as Director of the Federation and began his duties in September, 1924. He is editor of the *Journal of Personnel Research*.

The Federation has 28 member organizations and 62 individual members, widely distributed. Recent additions to the corporate membership include Massachusetts Institute of Technology, Division of Industrial Coöperation and Research; Yale University, Department of Administrative Engineering; and the Federal Board for Vocational Education.

The officers elected for the current year are President, Howard Coonley, member, American Society of Mechanical Engineers, President of Walworth Company, Boston; Vice Presidents, Alfred D. Flinn, Director, Engineering Foundation, New York; William Green, President, American Federation of Labor; Washington; Cator Woolford, Retail Credit Company, Atlanta; Secretary, Robert I. Rees, American Telephone and Telegraph Company, New York; Treasurer, Francis H. Sisson, Vice-President, Guaranty Trust Company, New York.

Personnel Research Federation is interested in several important projects in which the coöperation of engineers is essential. Studies of fatigue in relation to hourly output are impossible except in plants where excellent records of quantity and quality of individual production are kept. Similar measures of workers' efficiency are required in order to settle questions as to the best methods of training operatives; for example, the relative stress to be placed on speed and accuracy in the early stages of learning; or the degree to which rate of learning of a beginner predicts ultimate maximum ability.

Personnel Research Federation exists to further fundamental investigations on just such complex problems—problems which involve the human factor and hence call for joint attack by engineer, and biologist, psychologist, physician, physiologist or psychiatrist.

Further information may be had from the Director at the office of the Federation, 40 West 40th Street, New York.

The By-Product Processing of Coal

Methods of By-Product Processing and Converting Coal into More Valuable Forms—Carbonization of Coal—Complete Gasification—High- and Low-Temperature Carbonization—Typical Low-Temperature Retorts

By H. W. BROOKS,[1] FULLERTON, PA.

IF GOLD-BEARING quartz were combustible, little would be burned without first recovering its valuable metal content. Yet each year there are consumed (in the United States alone) nearly a half-billion tons of coal containing economically recoverable primary by-products considerably more valuable than the average gold content of quartz from the largest gold mine in the United States—the Homestake—on which the Hearst fortunes were founded. By conservative estimates, *profits* from conservation of these great natural resources even with our present relatively scant knowledge of the art would pay off our entire present national debt within twenty-five years. Yet in lieu of this their principal contribution to our civilization of today is in the production of that dirty, disease-producing, efficiency-killing monster evil of our cities—smoke. Can we of the power-plant industry burning 34 per cent of the nation's fuel, appreciate the enormity of the economic crime to which we are contributing? The author thinks not.

Owing to the limitations of space and the relative newness of the subject to power-plant operators, the author will endeavor to sketch in but roughly the major phases of the by-producting picture as we see it today, reserving a portion of his remarks for more specific treatment of that phase—carbonization at low temperatures—which he feels offers opportunities of major present-day interest to power-plant operators.

Methods of By-Product Processing and Converting Coal into More Valuable Forms

Present-day efforts looking toward by-product processing and conversion of coal into more valuable forms may be conveniently divided into the following six classifications:

1 Extraction by solvents
2 Conversion of coal into oil by hydrogenation
3 Conversion of coal or carbides into oil by gas synthesis
4 Complete gasification
5 High-temperature carbonization
6 Low-temperature carbonization.

Of the first—extraction by solvents—only about one-half of one per cent of liquid fuels may be recovered by present known technique—too small an amount to be of commercial promise.

Of the next two—conversion of coal into oil by hydrogenation or synthesis of water gas, carbon monoxide, and hydrogen or carbides at high-pressure-utilizing catalysts—it may be said that these are today uppermost in the minds of research workers in fuel engineering. Germany is at work producing a synthetic lubricating oil by processes similar to those she used in the production of the motor fuels menthanol and synthol. France, confronted by unusually difficult domestic fuel-oil problems, has established a synthetic-fuel laboratory under Audibert and a national research committee including several celebrated names. In England the experiments of Fischer on synthol and of both Fischer and Bergius on hydrogenation are being reproduced with encouraging results, according to Professor Nash of Birmingham University. A South Staffordshire coal, on hydrogenation, gave 37 per cent of liquid, a South Wales coal 26 per cent, and a Lancashire coal 61 per cent, these figures giving respectively 80, 56 and 130 gallons of liquid per ton of dry ash-free coal. Later results by Skinner and Graham and by Franz Fischer in Germany and the Badische Analin and Sodafabrik (purchasers of the Bergius patents) also show encouraging results with brown coals and lignites, lignite semi-coke yielding from 24.2 to 40.3 per cent of chloroform-soluble oil. After removing the carrying oil there remains a pitch product possibly capable of further hydrogenation and partial reduction to motor fuel. Dr. Bergius claims that one ton of crude oil can be produced by his process from two tons of coal at a cost of $6.90 covering total operating cost and fixed charges. A book The Conversion of Coal into Oils, by Drs. Fischer and Lessing, places before English readers the basic work of many investigators in this field. On the other hand Professor Fischer, the inventor of synthol, stated that neither his process nor the Bergius process has any practical importance for the immediate solution of the oil problem. The most favorable judgment that could be pronounced on the processes was that in their discovery the preliminary steps for beginning the transformation from a coal to an oil basis had become known. Assuming that these processes which have proved so successful in laboratory and small-scale installations can be proved remunerative on a large industrial scale, then from five to ten years, says Professor Fischer, the inventor of synthol, must elapse before the necessary plants can be erected for utilizing them. They would seem of more probable interest either to the steel, gas, or other industries having available large quantities of the gases necessary for synthesis, or to coal or oil producers or refiners making oil rather than power their desired end product.

In the field of complete gasification, interest continues to center in the Doherty process as installed at Washington, Pa. Though exact information is difficult to obtain, this three-unit plant is said to be carrying a load of about 20,000,000 cu. ft. of gas per day, producing gas of about 170 B.t.u. per cu. ft. One unit will take 120 tons of coal per day and make 75,000 cu. ft. of gas per ton of coal.

In the field of industrial heating where a gas richer than producer gas and cheaper than blue water gas is desired, complete gasification processes will doubtless find increasing favor as richer gases are produced at higher thermal and "dollar" efficiencies. Processes permitting separate extraction of primary and secondary distillation gases may make themselves of increasing interest to the gas and oil industries. It is difficult to see, however, how they may be of direct benefit to power-plant operators except under very special circumstances in the industries.

Carbonization of Coal

Of more immediate promise to the power-plant operator are the fifth and sixth classifications—high- and low-temperature carbonization. Of these two an article by the author recently published in the technical press (The Case for Low-Temperature Carbonization in America Today) concludes that low-temperature processes are likely to be economical, and hence more profitable to the power-plant operator, than high-temperature processes for the pretreatment of bituminous coal for the following reasons:

1 The oils recovered will be in volume two or three times larger and probably eventually will prove of distinctly greater value per gallon than the high-temperature tars, due to inherent chemical and physical differences.

2 This high oil yield would not glut the market with unmarketable coke to produce a reasonable percentage of our domestic oil requirements as would probably be the case with the low-oil-yield, high-temperature processes.

3 For power plants, low-temperature coke is better adapted to more efficient combustion in pulverized form.

4 Low-temperature coke fulfils the requirements for a smokeless and easily ignitable domestic fuel more desirable than high-temperature coke, when prices justify its sale for such purposes.

5 Low-temperature gases (from externally heated retorts) are richer, hence find a readier (and doubtless eventually a higher-priced) market.

[1] Consulting Engineer, Fuller-Lehigh Company. Mem. A.S.M.E.

Presented before the Midwest Power Conference, Chicago, Ill., Jan. 26 to 29, 1926, and before a meeting of the Metropolitan Section of the A.S.M.E., New York, N. Y., on Feb. 24, 1926. Slightly abridged.

6 Initial investment costs, hence fixed charges, are lower, as are also labor and maintenance costs.

7 The size of pipes, tanks, etc. required in handling the volatilized products (from externally heated retorts) will be smaller.

8 Operating at a lower temperature, the former, with properly designed heating surface, will consume less fuel about the retorts in order to maintain the proper carbonizing temperature.

9 Less heat will be lost in the condensing system because of the lower temperature of the various products evolved.

Dealing with certain recommended processes of low-temperature carbonization the article concludes:

1 The preferred process of low-temperature carbonization should either carbonize the raw coal in pulverized form, or pulverize and carbonize simultaneously, thereby furnishing a beneficiated coke to power plants which offer a permanent and continuing market without subsequent transportation charge on the yield of the only heavy low-priced product of the process.

2 The disadvantages—technical and economic—of low-temperature carbonization ascribed by its opponents largely or entirely disappear when the recommended methods are subjected to analytical consideration.

3 The processes recommended are not only technically but financially feasible, and apparently offer to American power-plant operators the only well-considered probability of future large reductions in fuel costs.

4 The most favorable location for laying down an early installation of low-temperature carbonizing equipment in connection with central power stations is in the Middle West. There cheap low-class non-coking or weakly coking bituminous coals can be converted into much-needed oils, rich gas, ammonium sulphate, and highly beneficiated, pulverized semi-coke more suitable for efficient power production than the original coal from which it is made. In such a plant, even at present market prices, the sale of primary by-products would probably pay the entire cost of the process, delivering to the boiler furnaces for power generation, fuel which represents clear profit, hence costing nothing.

5 In a large, efficiently operated central power station employing competent combustion engineers and boiler-room chemists to secure constantly the maximum continuous operation economies in fuel consumption (of which there exist an increasingly large number in the United States), there are already available competent personnel to manage, supervise, and operate the necessary additional carbonization equipment.

6 In combined gas and electric properties the operation of the by-product plant in connection with the central station would lessen coal storage and unloading expense, and would afford the gas plant a means of getting rid of waste products as well as a steady, cheap supply of enriching gas.

The gas and coke interests, however, who look askance at methods requiring radical changes in their present physical equipment or at the introduction of possible new competitors in their field, view with alarm the technical, commercial, and economic phases of low-temperature carbonization as a new prescription for fuel conservation. Dr. Rider of the Woodall-Duckham Vertical Retort and Oven Construction Company Ltd., of London, thus expresses himself in a private communication:

> We carried out a considerable amount of experimental work on a small works' scale embodying the process for the low-temperature carbonization of coal. This work, however, was stopped some 12 months ago because we had definitely arrived at the conclusion that low-temperature distillation was not the right method of producing the ideal smokeless fuel because of the extreme difficulty in disposing of the low-temperature oils on a commerically sound basis.

In the same mail another communication arrived from Col. N. G. Thwaites, Director of Low Temperature Carbonization Limited, probably the oldest organized effort in this field, which reads as follows:

> You will see, from what I am sending you, the yields of by-products obtained by this process, all of which find a ready market in this country. The oil products fetch a better price than petroleum products, and we have contracts offered us for our crude oil as high as 95 shillings per ton as compared with 75 shillings per ton at present prevailing for crude petroleum. With regard to the smokeless fuel we make, our contracts call for 250,000 tons a year, which can be extended to one million tons per annum as soon as supplies are available. All difficulties encountered have been overcome, and it has been established that the life of the retorts is anything from 5 to 10 years. This was one of our difficulties in the past, but with our present specifications we have no doubt that our retorts will stand up for a long period.
>
> With regard to the cost of plant, it may be stated roughly that £250 per retort to carbonize one ton per day will cover erection costs. A plant to carbonize 1000 tons of coal per day would cost in this country £250,000, and the net profits would be in the neighborhood of £140,000 per annum. The cost, therefore, of a plant can be recovered within about two years.
>
> Tests made by the Royal Air Force show that the motor spirit made by the "Coalite" process gives 15 per cent superiority in efficiency over motor spirit from petroleum, and the Air Ministry is very anxious to obtain large supplies.
>
> With regard to the fuel, we have been hitherto competing with best domestic coal, and have sold every ton we have produced at prices rather above than below the best coal on the market. With larger output we could, of course, reduce it very considerably, because of the large amount of revenue obtainable from the gas for industrial purposes and for town illuminating, besides motor spirit, Diesel oil and lubricants.
>
> In America, the most important consideration will be the use of powdered "Coalite" in place of pulverized coal. "Coalite" does not deteriorate when exposed to the weather as does coal, and in its powdered form is much less liable to explosion, besides giving greater efficiency than pulverized coal when blown under boilers, where complete combustion takes place.

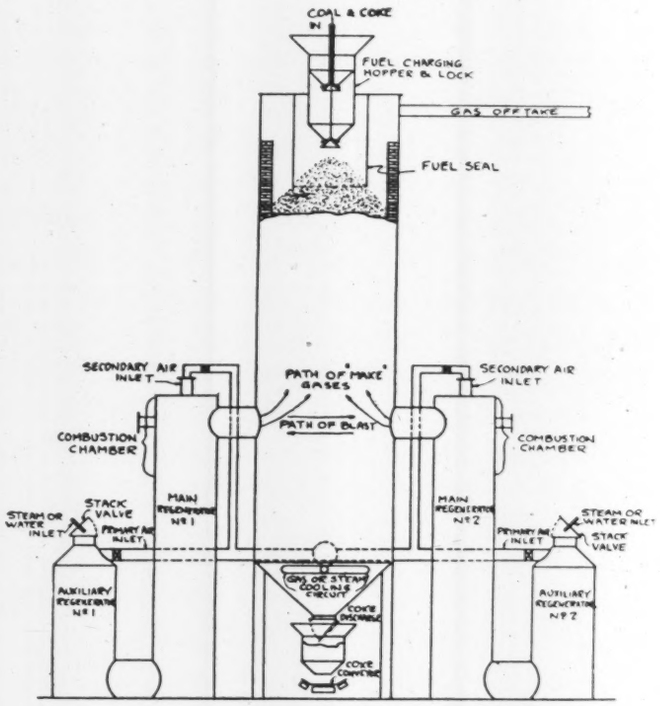

FIG. 1 DOHERTY COMPLETE GASIFICATION PLANT

Thus it would appear that success or failure depends not only on the point of view but the will to succeed and the methods pursued.

COMPLETE GASIFICATION

Of complete-gasification processes probably the most interesting is the Doherty process previously mentioned and now shown in Fig. 1,[2] which is an outline sketch of the experimental plant at Toledo, Ohio, and is shown merely to represent the principle of the operation. The purpose of the process is to completely gasify the coal and recover the by-products, the principal one of which is tar. The nature of the operation is such that the coal in its downward path comes in contact with hot gases which distil the tar vapors and carry them to gradually cooler zones. The tar vapors are eventually taken from the top, where they are carried through the coolers, scrubbers and tar precipitators for collection. The plant at Washington, Pa., consists of three units each 100 ft. high by about 15 ft. diameter at the base, with provision for a fourth unit. The ultimate plan is to operate the units in pairs, the second unit to gasify coke from the first, and the first unit to operate on a mixture of coal and coke. The piping of the gas is so

[2] Illustrations of this and other processes described are reproduced through the courtesy of A. C. Fieldner, Superintendent, Pittsburgh Experimental Station, U. S. Bureau of Mines.

arranged that the greatest flexibility in operation is secured. For example, both units of each pair are provided with offtakes for lean and rich gas, and the heat is recovered from the lean gas by recuperators. Hot gases from one unit may be circulated through the other unit if desired. Gas cooling is effected in a series of iron towers, some six in number, about 12 ft. in diameter by 30 ft. high, the cooling water being sprayed in from jets. The cooled gas passes through a Cottrell precipitator, which is said to remove the last traces of tar mist and dust. The tar is dewatered by means of Sharpless super-centrifuges. Coke is recovered at the base of the first unit of each pair of gasifiers. The charge in the gasifier rests on a mechanically actuated table from the base of which it is pushed into a hopper by several hydraulic rams which drive the coke toward the center of the shaft. This table has a hole in its

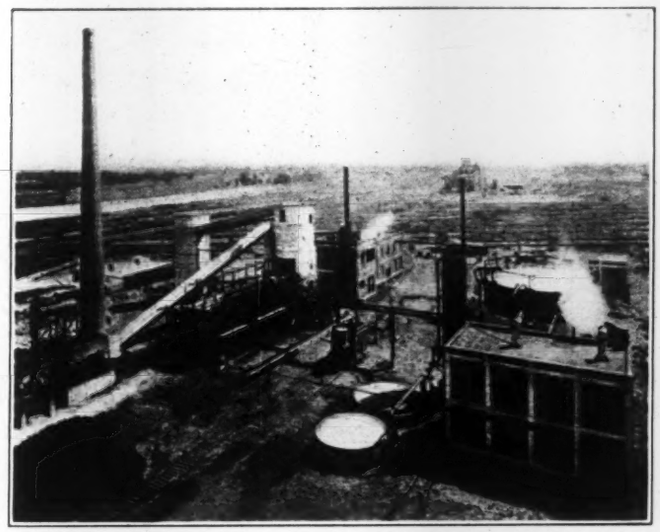

FIG. 2 PLANT OF CONSUMERS POWER CO., ZILWAUKEE, MICH., EQUIPPED WITH BECKER GAS OVENS

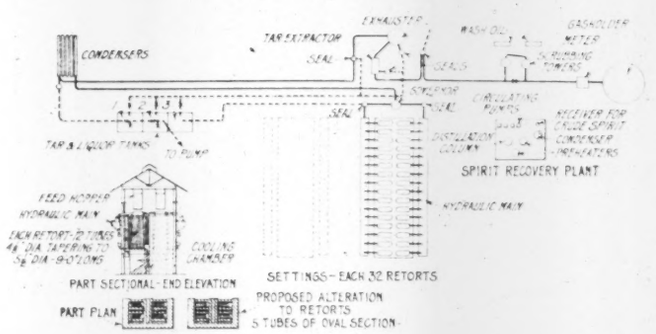

FIG. 3 PARKER RETORT INSTALLATION FOR THE LOW-TEMPERATURE CARBONIZATION OF COAL

center through which the coke drops, being carried thence by a belt conveyor to a screening plant, after which it is de-ashed by the Chance process. Coke from the gasifier runs about 20 per cent ash and the de-ashed coke runs about 12 per cent. The de-ashed coke is then conveyed to the top of the second gasifying unit where it is either charged directly or mixed with raw coal and recharged into the first unit. Though exact information is difficult to obtain owing to the newness of the installation, this three-unit plant is now said to be carrying 20,000,000 cu. ft. of gas per day. The heating value of the gas averages 170 B.t.u. per cu. ft. A unit will take 120 tons of coal per day and make 75,000 cu. ft. of gas per ton of coal.

HIGH-TEMPERATURE CARBONIZATION

High-temperature methods, being more or less familiar, will not be discussed here in detail. In the manufactured-gas industry there is today a strong tendency toward bulk-coal carbonization as the main source of gas, utilizing ovens instead of retorts. More than half of the coal gas distributed through city mains in the United States is now manufactured in by-product coke ovens, the amount so distributed exceeding 65 billion cubic feet in 1924. In 1925 there has been an increase exceeding 25 billion cubic feet of gas, thus showing the rather phenomenal rate of growth of some forty per cent per year.

Probably the most important single feature of this development has been the introduction of the Becker gas oven which is similar in every respect to the full-sized coke oven, except that it is only about half as long. One of the first of these installations (all of which have gone into operation within the past two years) is that of the Consumers Power Company, Zilwaukee, Mich., which is shown in Fig. 2.

The new short ovens have proven instantly popular. Already there are ten batteries in operation or under construction having

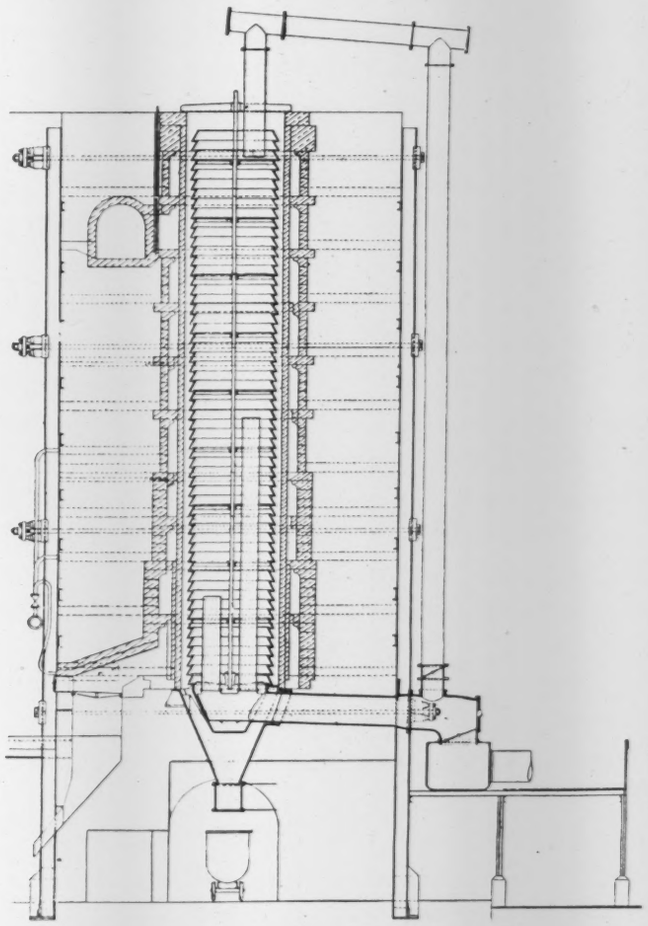

FIG. 4 ROLLE FURNACE FOR PROCESSING RAW BROWN COAL

a maximum daily coal-gas send-out of approximately 30 million cubic feet. This oven is adapted to moderate-sized cities having a daily send-out of 1,000,000 cubic feet or over. The optional use of either coal gas, blue water gas, or producer gas alone or in combination for heating the retorts and possible adjustments in coking time, provide a new-found working flexibility of material advantage to gas plants of low load factor.

For gas plants having a still smaller send-out, a vertical coke oven has been developed, the first battery of which has recently been put into operation with very successful results.

LOW-TEMPERATURE CARBONIZATION

Low-temperature-distillation apparatus may be divided into two classes, the first heated externally, heat being transmitted from the outside through a wall, and the second heated internally, carbonization being directly effected by hot gases passing through the charge. The apparatus for external heating may be further divided into stationary and rotary furnaces. The stationary furnaces may be of the shaft type, the horizontal type, or the tunnel-kiln type.

Vertical Retorts. If the production of low-boiling benzine and gas is aimed at, the volatile of the coal is best distilled by applying external heating. The relatively low temperature of 400 to 500 deg. cent. required for this purpose admits of the use of retorts of steel or cast iron, which are preferable to refractory material (except silicon carbide) on account of their impermeability to gas and greater thermal conductivity. Stationary retorts offer the advantage over rotary furnaces that they do not require a power drive. The rate of distillation depends upon the thermal conductivity of the walls and the thickness of the layer of coal. In view of the low thermal conductivity of coal and semi-coke the layer should be as thin as possible to keep the carbonizing period reasonably short and provide for an economical throughput of the retort. An attempt to raise the throughput by more intense heating of the retort walls would lead to superheating the tar vapors, diminish the tar yield, and lower the quality, i.e., its hydrogen percentage. In other words, a product would result which in quantity and character would approximate coke-oven tar. This is a defect of all processes which profess to produce primary tar, but claim at the same time to realize very high yields of ammonia. These become possible only at temperatures from 600 to 800 deg. cent., while in normal low-temperature tar production most of the nitrogen remains in the semi-coke. It may be subsequently recovered as ammonia by gasification of the semicoke much more completely than would be possible by applying higher carbonizing temperatures. To avoid hanging up of the charge of highly caking or swelling coals and difficulties in discharging, vertical retorts are generally given a suitable taper.

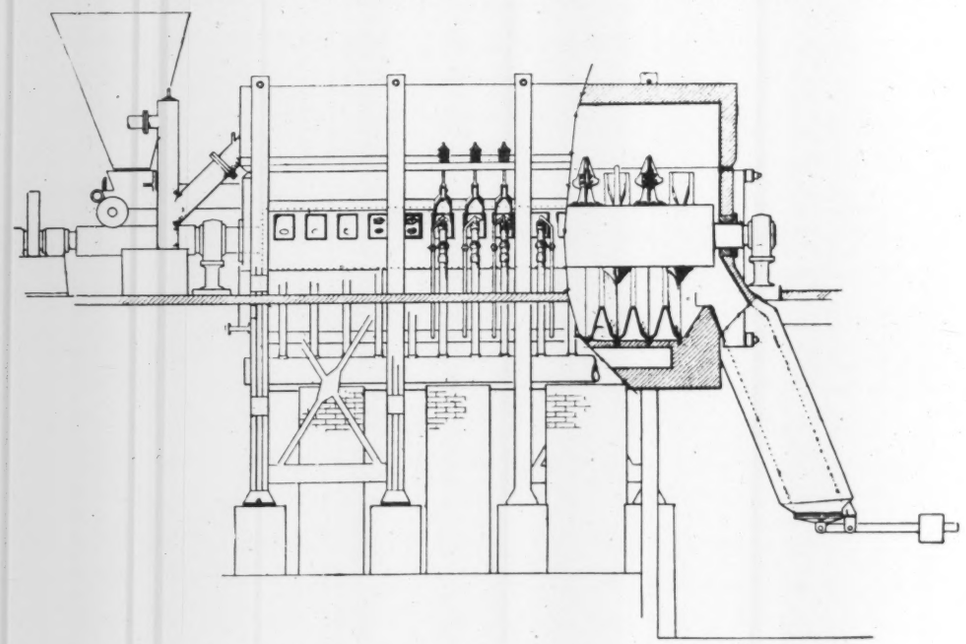

FIG. 5 SIDE ELEVATION OF MCINTIRE LOW-TEMPERATURE COAL-CARBONIZING RETORT
(Development of the Smith or Carbocoal Retort.)

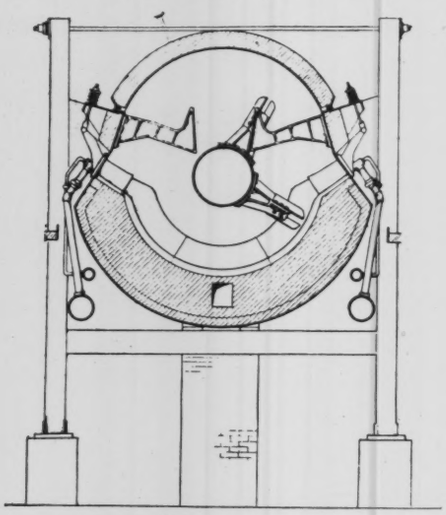

FIG. 6 END ELEVATION OF MCINTIRE RETORT SHOWN IN FIG. 5

The British "Coalite" process, invented by T. Parker, was probably the first to be commercially applied for the low-temperature carbonization of coal and was on this principle. The first patent was granted in 1890, but the principal process patents were taken out in 1906, 1907 and 1908. An installation consisting of two batteries of 32 vertical retorts, each battery being designed to carbonize 50 tons of coal per 24 hours, has been installed at Barugh, Barnsley, in Yorkshire, and is shown in Fig. 3. Each retort consists of an iron casting in one piece, containing twelve vertical tubes tapering from $4\frac{1}{2}$ in. internal diameter at the top to $5\frac{1}{2}$ in. internal diameter at the bottom, and 9 ft. long. The retorts are heated by burning a mixture of the low-temperature gas and producer gas in the combustion chamber surrounding the retorts. Four hours are required to coke the charge at 650 deg. cent. It is claimed that in this retort—which has been evolved after trials of numerous other designs—a special cast iron is used that will not grow or distort at the temperature of carbonization. Swelling and non-swelling coals are blended in the charge so that the resultant coke contracts sufficiently to be discharged easily.

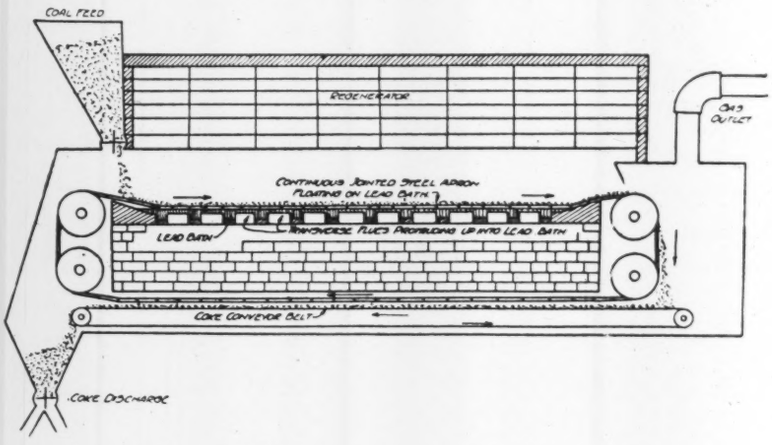

FIG. 7 PIRON RETORT OF THE TUNNEL-KILN TYPE

There is some question whether after a lengthy period of operation such retorts would not distort or warp sufficiently to make it difficult to discharge the coke. Extensive tests on this installation have been made by the Fuel Research Board in England.

Retorts of this type for the treatment of brown coal and oil shales have long been used. These materials present no difficulty in caking or swelling, and if they are rich in tar, the properties of the solid residue are of no consequence as in the case of coal. The plants were not designed for producing primary tar. There was no interest in undecomposed bitumen, and the object was the production of well-crystallized paraffin wax, gas oil, and fuel oil. Even the production of benzine from the carbonizing gas was not a decisive factor in these older processes. In the central German carbonizing industry, the Rolle furnace (Fig. 4) has been used for many years. It is intended for the processing of raw brown coal, which air-dried by suitable storage admits of continuous working. The height of these retorts is about 33 ft. The retort

is built of firebrick and is surrounded by flues. The coal slides down between the walls of the retort and an inner cylindrical body built up Venetian-blind fashion, of a series of bells resting upon one another through which the gases and vapors find an outlet. Large numbers of such retorts have been in operation for many years in central Germany.

Horizontal Retorts. Of the externally heated retorts of the horizontal type probably the most interesting in America is the McIntire retort shown in Fig. 5. The coal is fed in at one end and the semi-coke discharged at the other. As shown in Fig. 6, a series of paddles carried on a central rotating shaft moves coal along the bottom of the retort, agitating it at the same time.

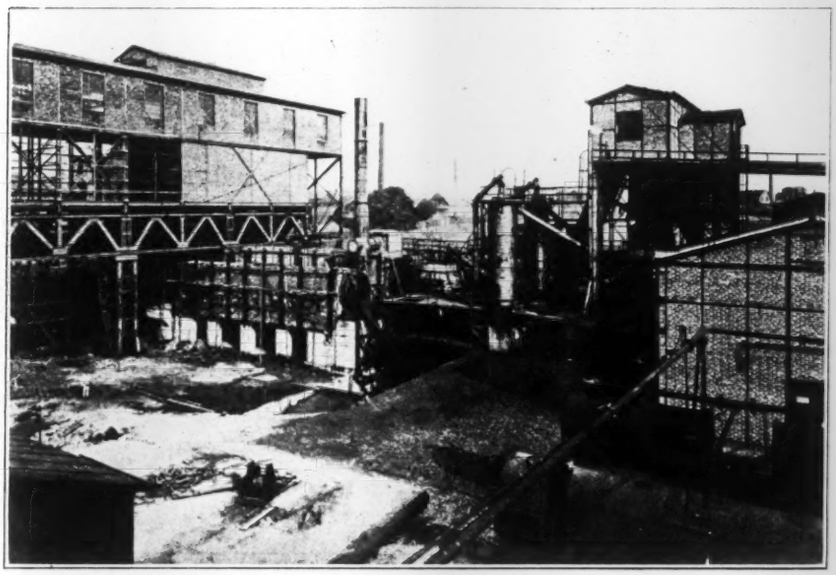

FIG. 8 ROTARY RETORT INSTALLATION AT THE THYSSEN WORKS, MULHEIM AM RUHR, GERMANY

The heating is done along the bottom surface over which the coal is being conducted, and the resulting coke is discharged in small pieces due to the agitation. This fine coke can be briquetted with a pitch binder and recarbonized and used as a producer fuel, or screened out and fired in pulverized-fuel furnaces. A retort of this design has been in operation two years, during which time it treated 11,500 tons of coal from which was recovered 350,000 gal. of oil.

Tunnel-Kiln-Type Retort. Representative of the tunnel-kiln type retort are the two well-known Ford installations of the Piron retort, one of which is shown in Fig. 7. In this instance the coal is conveyed through a closed retort on an iron conveyor which floats across the surface of a molten-lead bath. The heat of the lead devolatilizes the coal, and the coke is carried out and discharged from the conveyor belt. It is claimed that a layer of coal $\frac{1}{2}$ in. thick is completely carbonized in five minutes at a temperature of 650 deg. cent. The firebrick retort is about 50 ft. long. Gas is the source of heat for maintaining the molten-lead bath at the required temperature, and the products of combustion pass through narrow passages under the bath into checker brickwork regenerator settings overhead. The semi-coke delivered is not in a form suitable for use as a domestic fuel, it being the intention to pulverize the greater portion of the fuel and use it for steam-raising purposes.

Rotary Retorts. Rotary retorts have found special favor in Germany, and to some extent in England. The first rotary retorts of really large dimensions were designed by Thyssen & Company at Mulheim am Ruhr a few years ago. At present there is a plant of 100 tons per day throughput at the Thyssen works, another at the Hamburg Gas Works, and two units at the Prince Bismarck Colliery. The Thyssen retorts are of surprising simplicity and capacity. The iron drums are built in one piece 78½ ft. long by 8½ ft. in diameter. Fig. 8 shows an installation of this retort at the Thyssen & Company plant. The coal is fed into the rotating tube at one end and is carried through the length of the tube in two hours by means of helical screw lifters riveted to the drum, and drops out at the other end in the form of semi-coke. The iron drum runs in a chamber which is fired with producer gas, these chambers being heavily lagged against heat losses. The distillation gases leave the drum together with the tar vapors at the same end as the semi-coke. The principal difficulty with which the Thyssen plant has to contend is the formation of dust. This dust trouble is particularly pronounced in large rotary retorts because the friable semi-coke is kept in rolling and tumbling motion and the dust thus continuously stirred up. As the presence of dust in the tar interferes with the separation of the water and lowers the value generally, it is necessary to remove it before the tar is condensed. Special dust separators are thus required to throw down the dust from the hot gases. Even with such dust-collecting equipment the tar is likely to contain 1 to 2 per cent dust, which seriously detracts from the commercial value of the low-temperature pitch. The retort at Mulheim, said to have been operating continuously for a period of five months, shows no signs of warping or bends in the long rotary shell.

In England the most interesting rotary retort is the Fusion retort which is being offered by Vickers, Limited, and is shown in Fig. 9. The material to be treated enters the rotary retort through an automatic feed valve, passes through the retort tube where it becomes heated, and is discharged at the other end through an automatic valve to a receptacle. To prevent sticking of the material on the inside of the retort a star-shaped breaker is employed. This consists essentially of steel plates *E* radiating from a central spider which extends

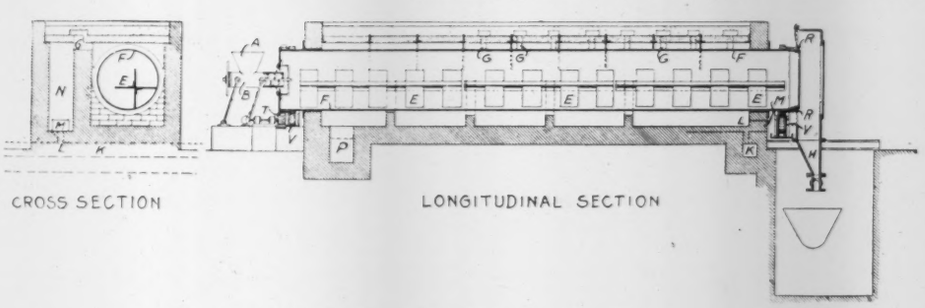

FIG. 9 THE "FUSION" ROTARY RETORT

from end to end in the retort, the entire breaker being free to tumble over as the retort rotates. These breakers are said not only to stir the coal and expose fresh surfaces to the hot walls of the retort, but also to give a hammering and chipping action on the sides of the retort, keeping it free from caked material. The retort is heated by the combustion gas from a producer-gas plant or the products of combustion of a hand-fired or mechanically operated furnace. The products of combustion pass into the combustion chamber *N*, which is located on one side of the retort. They enter the heating chamber through a number of ports *G* properly placed and capable of regulation at the chamber in such manner that the temperature at any part of the retort can be controlled. The heating gases are passed around the rotary retort and leave the heating chamber at the feed end through *P*. They flow in a direction opposite to that of the flow of material through the retort.

INTERNAL HEATING

In general four heating media have been attempted in internally heated retorts: superheated steam, hot producer gas, hot coke-oven gas, and hot flue gases. There is little doubt that steam is

the most suitable direct heat carrier, because it can be separated from the products of distillation by suitable cooling so that these products are obtained in an undiluted form. Such a process, however, gives little commercial promise, and the operation is very expensive for complete tar recovery. It is not sufficient merely to cool the large amount of steam necessary to 212 deg. fahr.; the steam must be condensed to water to make the extraction of benzine possible. This involves further steam raising, a combination which even with good heat exchange means a large expenditure of fuel and cooling water. Owing to their improbability of commercial success the several methods employing this principle will not be described.

Hot Producer Gas as a Heating Medium. Maclaurin in Scotland effects carbonization by means of hot generator gas instead of superheated steam as shown in Fig. 10. The Maclaurin retort is essentially a by-product-recovery gas producer in which part of the semi-coke is burned to producer gas, the sensible heat of which carbonizes the descending charge of coal. The experimental producer at Grangemouth, Scotland, is of square cross-section, about 45 ft. high by 8 ft. wide at the widest part. The air blast is introduced about 12 ft. above the discharging doors, through a large number of narrow ports in opposite side walls, and also by similar ports in a dividing wall which is carried across the center

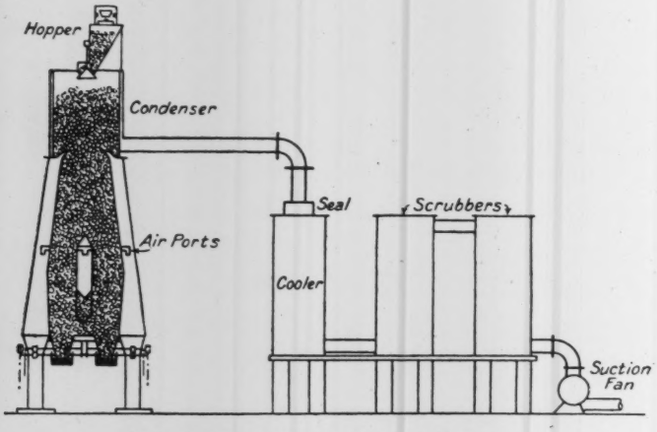

FIG. 10 MACLAURIN CARBONIZING PLANT

of the retort at the same level. The coke is cooled in the zone below the air port, steam being injected at the discharging doors. A part of this steam ascending through the coke becomes heated and partly decomposed into water gas, thence passing upward and mixing with the producer gas formed in the combustion zone. The raw coal is discharged from an elevated hopper through a bell into the top of a cylindrical steel tank 8 ft. in diameter by 10 ft. high, resting on the brickwork at the top of the retort. The tank serves as a condenser for the oils and tars which drain down the side of an inner steel cylinder which dips into the well formed by a dished flange at the bottom of the tank. From the annular space between the tank and the cylinder, the gases are led off to tower coolers and scrubbers. The plant is continuous in operation, and a retort of the dimensions given contains about 30 tons of coal. It may be run either for complete gasification or for production of smokeless fuel, the only adjustment necessary in changing over consisting of the regulation of the air blast and gas outlet valves. A 100-ton plant employing this process has recently been installed at the Dalmarnock Gas Works in Glasgow, Scotland, and is being watched with great interest. The Maclaurin carbonizer is quite similar to the Hood-Odell lignite carbonizer, which has been the most promising method yet tried on brown lignite. An experimental retort of this type is shown in Fig. 11.

The big advantage of this type is that the heat is generated within the carbonizer and transferred without loss by a gaseous medium to the surface of each particle of fuel. It has no moving parts to get out of order and is constructed of standard refractory

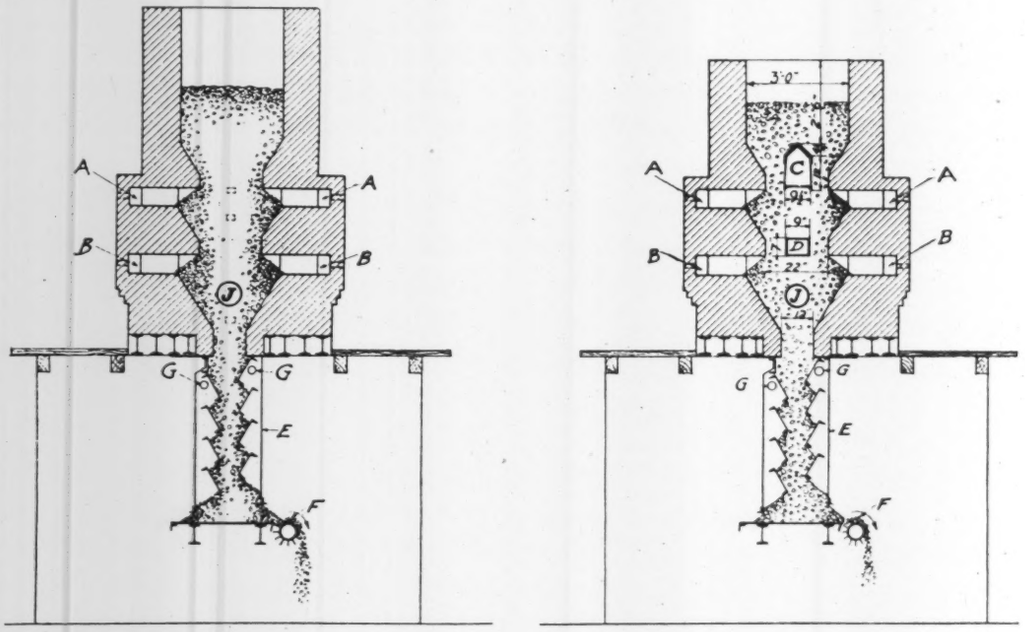

FIG. 11 EXPERIMENTAL HOOD-ODELL RETORT FOR CARBONIZING LIGNITE

materials that have stood the test of experience in gas-works and coke-oven practice. The first cost is relatively low and the output per unit is higher than most low-temperature processes. The disadvantage is that the semi-coke is small, bulky, and somewhat friable. Although smokeless, it is not likely to be popular for domestic use for these reasons. The large amount of low-calorific-value gas produced, limits the use of the Maclaurin producer to such places where the gas may be utilized without transport, such as gas-works retorts, glass or ceramic works, and metallurgical plants.

The Neilson retort shown in Fig. 12 also makes use of the sensible heat of producer gas for the carbonization of coal. Neilson's process differs from Maclaurin's in the fact that it employs the rotary inclined retort. In the Neilson carbonization plant erected at Silkstone, Yorkshire, England, the hot gas from the producer is passed by a short connection into the discharge end of an inclined rotary retort. Coal is fed into the upper end traveling toward the other end over a system of baffles designed to secure intimate contact of the hot producer gas that enters at the lower end of the retort with all parts of the coal charge. This process was originally designed for installation at steel plants to recover and utilize the sensible heat of producer gas for low-temperature distillation, using the resultant semi-coke as a gas-producer fuel. The long rotary is lined with firebrick, and a steel shell is inserted on the outside to reduce heat losses to a minimum.

Hot Coke-Oven Gas as a Heating Medium. Sutcliffe and Evans have conducted researches into the problem of low-temperature carbonization, with the object of obtaining a smokeless fuel. By mixing coal rich in gas with lean or oxidized coal they propose to improve the physical structure of coke, the various coals being ground and briquetted at high pressure without the addition of a binder. Their briquets are described as being sufficiently hard and strong for carbonization in high vertical retorts. Provided that a high enough compressive strength of the briquets can be obtained, these inventors consider retorts with a daily throughput of 1000 tons possible. They propose to effect the low-temperature carbonization of their compressed fuel by forcing hot coal gas

through a perforated cylinder axially mounted in the vertical retort so that it takes up the products of carbonization. The gas is continually reheated in two regenerators, one of which is giving up its heat to the return gas while the other is brought up to temperature again by the combustion of the surplus carbonization gas, with the usual arrangement for changing over.

Carbonization by Means of Flue (or Re-run) Gases. Undoubtedly the most interesting recent development to American operators

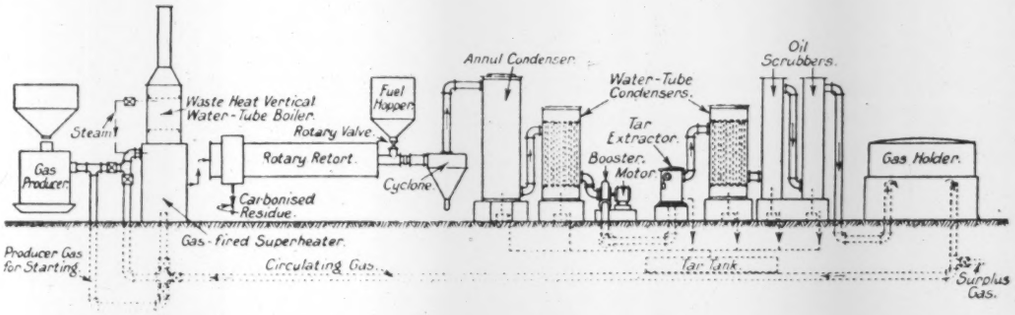

FIG. 12 NEILSON PROCESS USING SENSIBLE HEAT OF PRODUCER GAS FOR CARBONIZING COAL

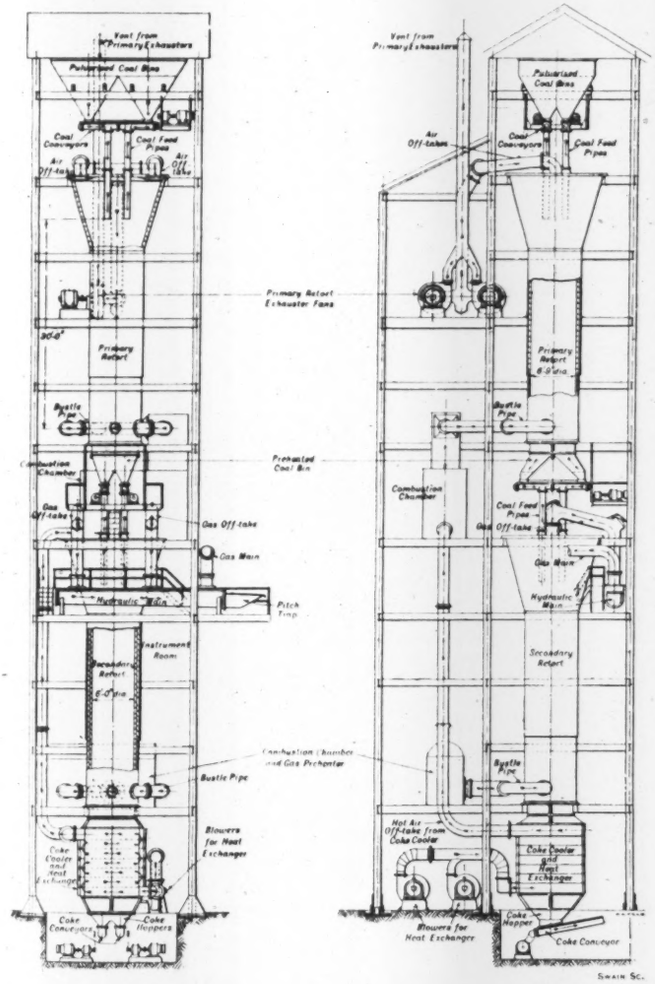

FIG. 13 200-TON MCEWEN-RUNGE COMMERCIAL-SCALE EXPERIMENTAL RETORT

is the announcement of the installation of a 200-ton McEwen-Runge commercial-scale experimental retort at the plant of the Milwaukee Electric Railway & Light Company. The operation of this plant is shown in Fig. 13. It utilizes the principle of carbonization of pulverized coal in suspension by means of flue (or re-run) gases. The powdered coal is dropped into an internally heated tower where it will come in contact with an upward current of hot inert gas. The extremely large surface presented by the finely divided fuel particles insures a rapid transfer of heat so that distillation is effected during the time the fuel falls from the top to the bottom of the tower, a distance of about 30 ft. When using coals having a tendency to agglomerate, advantage is taken of the fact that by preheating the coal to an average temperature of 600 deg. fahr. the coking tendencies of the particles are destroyed. It is then passed through another tower, immediately beneath the first one, where the remainder of the volatile matter is distilled by passage through a countercurrent flow of gas at an average temperature of 1050 deg. fahr. The gases and oil vapors are carried off to scrubbing and cleaning apparatus and the pulverized semi-coke is conveyed from the bottom to be burned under boilers in pulverized form.

SUMMARY AND CONCLUSION

It has been the intention in this paper to paint broadly the picture presented by our present-day knowledge of by-product processing of coal, indicating the principal methods employed and their probable field of application. Low-temperature carbonization has been dealt with at some length in the belief that, of all of the methods indicated in some of its forms it offers promise of maximum interest to the power-plant operator. It must never be supposed that low-temperature distillation of coal will ever prove a panacea for all fuel problems, as we are sometimes led to believe. It has been estimated that of all the new enterprises only one in seven achieved success. Watt's steam engine—perhaps the greatest invention of all—rendered bankrupt one concern and very nearly a second before it became a paying proposition. So today it is not claimed that low-temperature carbonization can be said to be a demonstrated commercial success, but the facts that the British House of Commons are today being asked for a £10,000,000 subsidy to develop low-temperature carbonization, and that millions have been spent and are being spent in its development both here and abroad, lead to the belief that we are on the eve of a new era in the economical utilization of coal, and that it behooves each of us to be on the alert to hasten the day of demonstrated commerical practicability when new and undreamed-of profits undoubtedly await us.

Hygrometry in Mining Practice

THIRD report of the Committee on the Ventilation of Mines of the Midland Institute of Mining Engineers. In discussing the wet-and-dry-bulb hygrometer the author calls attention to the fact that the ordinary unventilated type of wet-and-dry-bulb hygrometer is useless as an instrument of precision, but can be converted into a very satisfactory instrument by arranging for a current of air exceeding a definite velocity to be drawn past the thermometer bulbs. In the Assmann psychrometer the thermometers are fixed in two adjacent parallel tubes and air is drawn through these tubes and over the bulbs by means of a small clockwork suction fan. In the modified type of this instrument (Casella) the fan is driven by a small 10-watt electric motor.

The author also enters into the discussion of the various psychrometrical tables, such as Jelinek's, British Meteorological Office Tables, Marvin's Tables (U. S. Weather Bureau), Jones', Prussian Meteorological Institute, and Glaicher's Tables. He comes to the conclusion that while all the generally accepted tables will give reliable results, yet in none is this information presented in an entirely acceptable manner for general mining purposes. The new tables of Jones (based on Professor Ferrel's formula) are perhaps the best available at present, but there will be many who prefer moisture to be expressed in grains per cubic foot (at standard temperature and pressure) rather than in grains per pound of dry air, since underground measurements are always made in cubic feet. A bibliography is appended. (Prof. Douglas Hay and W. E. Cooke in *Transactions of the Institution of Mining Engineers*, vol. 70, pt. 3, Dec., 1925, pp. 152–174, 5 figs., *egA*)

The Tension Ratio and Transmissive Power of Belts

Points Brought Out in the Discussion of an Annual Meeting Paper Presented by C. A. Norman

IN A PAPER bearing the same title and presented at the A.S.M.E. Annual Meeting at the first session of the Machine Shop Practice Division, December 1, 1925, Prof. C. A. Norman described an investigation of the increase of transmissive power with slip which was conducted at the Ohio State University on an apparatus patterned after that of Friedrich on rubber, leather, and fabric belts. The results of the investigation were given in the form of curves and the conclusions drawn from the tests noted in an abridgment of the paper published in MECHANICAL ENGINEERING for December, 1925, pp. 1111–1113.

In a written discussion which he contributed, Robert W. Drake[1] said that the design of most belt drives was based on data as to running conditions with very little thought concerning starting conditions. The author's method of determining the variation of friction coefficients with slip gave results which were unquestionably valid under starting conditions, whatever questions might be raised as to the validity of conclusions drawn from such tests and extended to include belts operating at higher speeds. A continuation of his curves to the highest possible slips of, say, 50 or 100 ft. per min. and a set of curves at 100 lb. per in. would be useful.

Several cases of drives conservatively designed for running conditions which gave regular or occasional trouble under starting conditions, had led the writer to analyze starting conditions rather closely in a number of drives. The conclusion arrived at was that in at least 20 per cent of such belt drives starting conditions should really control the design. A few examples of difficult starting conditions might prove illuminating.

Many steel-mill buildings, forge shops, etc., containing furnaces, required little or no artificial heat. In such buildings belt drives were most severely tried when they started up on a winter Monday morning with the oil "frozen" in the lineshaft bearings. Machines such as grinding wheels, boring mills, shears, presses, and coal crushers, had a heavy inertia load. At starting the maximum available torque of the driving motor was developed for an appreciable time during acceleration. This was true also of machines having rotating parts of moderate mass but operating at high speed.

To estimate the torque to be transmitted by a belt during the starting period sometimes offered difficulties. In an a.c. motor drive there was always an upper limit in the maximum torque of the motor with full voltage applied. Often in the case of large motors, experience with similar drives indicated that this torque might be safely reduced to about 70 per cent of this maximum, (85 per cent tap on reduced-voltage starter). It was well to make sure that it was not sometimes necessary to start such a motor "on the line."

In the past very many such drives designed liberally for running conditions and using belting having a friction characteristic similar to that shown in Fig. 9 of the author's paper had given "comparatively little" trouble at starting. Developing for five to thirty seconds, more than double the effective tension ($T_1 - T_2$) for which they were designed, they could be persuaded to stay on the pulleys, and transmitted enough torque at very high slips so that they accelerated with fair rapidity. The belts were not "burned" unduly by friction at the part in contact with the pulley during starting. In considering the characteristics of a fabric belt such as "Rubber A" in the author's experiments, it was evident from Figs. 8, 7, and 6 (in reverse order) that the tension ratio versus slip curve drooped more and more with heavy slips at excessive tensions. To transmit the maximum starting torque of a squirrel-cage induction motor, for example, say, $1^1/_2$ to 2 times full-load torque, or of a wound-rotor induction motor, say, 2 to 4 times full-load torque at very high slips, such drives must be designed far more liberally than was the case with leather belting.

Perhaps a majority of belt drives were designed for an average steady-load condition. Yet not infrequently a motor operating at an average load within its rating, carried for several five-second periods in each five-minute interval swings of double its rated load. Belts of some materials would carry these surgings satisfactorily with a somewhat increased slip. Belts of other materials, it was evident from the trend of Professor Norman's curves, could be applied to such drives only by using very low unit tensions in designing the drive, if the design was based on average effective tension ($T_1 - T_2$) rather than on maximum effective tension. Due to lack of data on such maxima, most designs were based on average loads.

E. O. Waters[2] wrote that the author had advanced a very interesting theory to account for the fact that the traction of a leather belt increases with the slip, and this argument could be applied equally well to gum-treated fabric belts, of the types reported in the paper. If the heat developed by the friction of leather on iron melted out the internal lubricant and created a semi-viscous drag, why should it not also be supposed that this heat softened the gum with which a fabric belt was impregnated, and created a drag of similar nature? This line of reasoning would apply equally well to impregnated fabric, balata, and so-called rubber belts.

The very interesting curves in Figs. 6, 7 and 8 brought out strikingly the fact that the coefficient of friction increased as some function of the slip. This had been a matter of common knowledge in the past as far as leather on iron was concerned, but other factors governing the condition of the belt were so variable that the effect of slip had not been formulated in any definite manner. Possibly Barth's formula for the coefficient of friction, $\mu = 0.54 - \frac{140}{500 + V}$ in which μ increased with the velocity, up to a definite limit, was the nearest approach to any such formula. But the present paper showed that the effect of slip was so pronounced that it might easily overshadow other variables. The tests might be continued until a large mass of consistent, authentic data had been obtained, and then a simple expression for μ deduced in terms of the slip—or in terms of some other quantity related to the slip, but more easily measurable under practical working conditions. For instance, the chrome-tanned leather belt in Fig. 7 showed a variation of $\frac{T_1}{T_2}$ from 3.2 to 9.75, indicating, for 180 deg. of contact, an increase in the coefficient of friction from 0.38 to 0.72.

There was another point of view that must be kept in mind in designing a belt transmission. Laying out a belt drive was a problem in economics quite as much as mechanics. For instance, a pair of shafts might be connected by large-diameter pulleys and a light, high-speed belt, or by small pulleys and a wide, slow-speed belt. In one case there was a combination of expensive pulleys and low-cost belt, and in the other, cheap pulleys and an expensive belt. In the final analysis, the combination that had the lowest combined cost must be selected. Likewise there were several different belt sizes that might be selected to handle a given effective pull at a given speed. The small sizes would cost less in the first place, but would run with high initial tensions, a great deal of slip, and short life.

W. M. Sawdon,[3] in discussing Professor Norman's paper, said that the method of testing employed by the author was used by him, with what appeared to be very good results, for testing brake drums in 1912, and an effort had since been made in the laboratories of Sibley College to obtain, by this method, data which could be used in predicting the relative value of belting for transmitting power. For the latter purpose the method had not worked out so well.

[1] International Harvester Co., Chicago, Ill. Mem. A.S.M.E.

[2] Asst. Prof. of Mechanical Engineering, Yale University, New Haven, Conn. Mem. A.S.M.E.

[3] Cornell University, Ithaca, N. Y

It was generally recognized that there was a slippage, commonly known as "creep," taking place when a belt was transmitting power, and this creep was a function of both the elasticity and of the surface condition of the belt. In general the term "slip" was used to include both creep and actual slip, but, for certain purposes the distinction must be kept clearly in mind.

With light or even moderate loads there was no relative velocity between belt and pulley near the point at which the belt rolled on to the pulley, but there was a relative motion near the point at which the belt rolled off the pulley. This was a case of creep without real slip and it was due to the contraction of the belt as it passed from the tight side to the loose side on the driver pulley, and to the elongation of the belt as it passed from the loose side to the tight side of the follower pulley.

As the load was increased a point was reached when there was also impending slip of the element of the belt which was just rolling on to the pulley. There existed then a condition in which there was relative motion between the pulley and the consecutive elements of the belt along the whole arc of contact with the relative velocity varying from zero for the element just coming on to the pulley, to a maximum relative velocity for the element just leaving the pulley. This was the limit of creep or the load at which the creep was maximum. Any additional load caused real slipping and affected all the elements alike, but, under no circumstances did all the elements on the arc slide with the same velocity when considering both creep and real slip combined.

It was quite evident that with the belt held fast and the pulley slowly revolved all the elements of the belt which were in contact with the pulley were sliding over the pulley with the same velocity, and the condition was very different from the condition when the belt was transmitting power.

Many drives must for safety be designed to ordinarily operate within the creep range, reaching the real slip range only when overloaded or in starting up.

The creep range for two pulleys was usually somewhat less than two per cent for leather belts, but varied with the quality and kind of belt. This was also about the limit of power loss permissible for many purposes. To such cases the author's method of testing did not apply at all.

R. F. Jones[4] wrote that some of the conclusions in Professor Norman's paper had been frequently corroborated at Cornell University, especially that one which indicated that the tension ratio and its correlative effect transmissive power increased with slip. The writer also agreed with Professor Norman in his conclusion that the increase of tension ratio with slip was greater with run-in leather belts than with run-in rubber or other textile belts.

The belt-testing apparatus at the Engineering College of Cornell was a development of the original Lewis machine. It consisted of two electric dynamometers, one driving the other through the test belt. Measurements could be taken of the hp. delivered, the total slip, the sum of the tensions less centrifugal force, the r.p.m. of either pulley, the center distance, the arc of contact on either pulley, and the sag of the loose strand. Any combination of pulleys between 4 in. and 36 in. might be used.

There was one important influence present with a running belt which was not present in the friction tests described and which might have considerable effect on the results, namely, the effect of creep due to the elasticity of the belt. Creep took place in all belts more or less, depending on the conditions, and was likely to cause most of the total slippage up to 1 per cent, and it sometimes constituted the entire slip up to 1.76 per cent or more. In Fig. 1 was an example of the slip distribution on a 4-in. light double leather belt while running under load. This was obtained in a study of creep and slip now in process at Cornell. These figures were subject to some experimental error but were approximately correct. There was a wide difference in the rate of slip at different points on the pulley, and this condition was quite different from the constant rate of slippage at all points necessary with the author's machine. The fact that there was little or no slip indicated at the point where the belt came on the pulleys proved that the entire slippage was creep. The total slip on both pulleys was 33.5 ft. per min. or 1.68 per cent of the belt speed of 2000 ft. per min.

The effect of creep on the test data of a running belt was evident from the curves of Fig. 2. Here the difference of tensions ($T_1 - T_2$) or effective driving tension was plotted against the percentage of slip for power tests at 1000, 2000, 3000, 4000, and 6000 ft. per min. At any slip up to 2 per cent the curves practically coincided, although the rate of slip in ft. per min. varied with the belt speed. No increase in effective tension resulted from the higher rates of slip at higher speeds because the elasticity of the belt determined the creep, and in this case the writer had all creep up to where the curves separated. They fell together because of the change in length, and hence the per cent creep of any section of the belt as it passed from one side to the other remained about the same for the different belt speeds, at the same initial tension. Many belts did not creep as much as this without slipping, but creep was certain to exert an important influence. It was obvious that the friction-

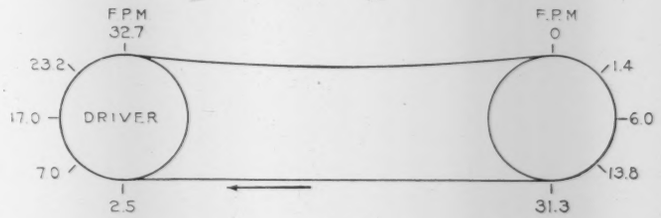

FIG. 1 SLIP-DISTRIBUTION TESTS MADE BY R. F. JONES AT CORNELL UNIVERSITY, INDICATING DIFFERENT RATES OF SLIP AT DIFFERENT POINTS ON THE PULLEY

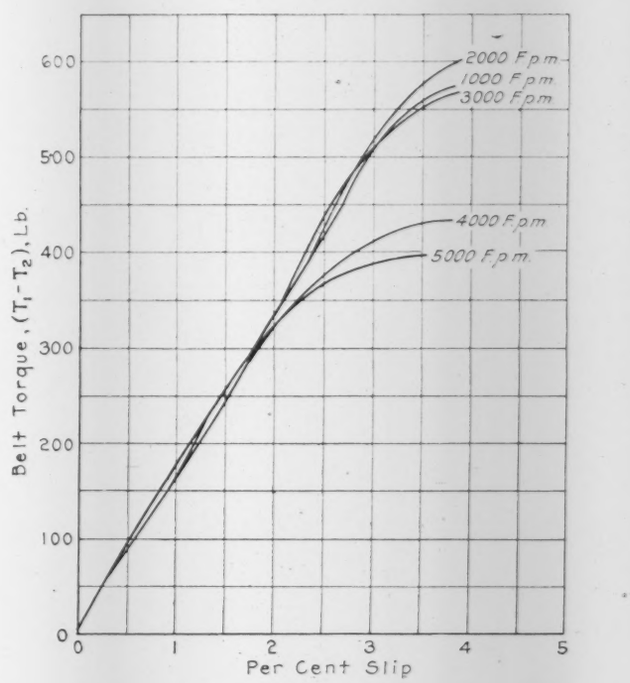

FIG. 2 BELT TORQUE AS AFFECTED BY PERCENTAGE OF SLIP AT DIFFERENT PULLEY SPEEDS. FROM TESTS BY R. F. JONES

pulley tests were not affected by creep, and conclusions drawn from such tests could not be strictly applied to running belts. However, they might have a certain value for comparative purposes.

The curves of Fig. 3 were computed from the same data as those of Fig. 2, using the familiar formula,

$$\frac{T_1 - T_c}{T_2 - T_c} = e^{f\theta}$$

The wide difference between the various curves for any value of slip was due to creep.

Through the courtesy of Dr. R. R. Tatnall, of J. E. Rhoads & Sons, the writer had obtained data comparing the friction-pulley test method and the power test method on the same belts as shown in Fig. 4. The two belts had been well run in, and the friction test curves were an average of data from several different pieces of each belt. The range of slip covered was from about 1.2 per cent to 2.1 per cent at 2500 ft. per min. belt speed, which limits would

[4] Sibley College, Cornell University, Ithaca, N. Y.

not be exceeded in normal operation. Much higher tension ratios were obtained using the pulley test method than when the belt was running under load. This seems to be conclusive proof that the friction test has little value as a test of performance.

The effect of running in was most important in any kind of tests on leather belts. The curves of Fig. 6 showed how a 4-in. single leather belt improved with a few hours of running. The belt

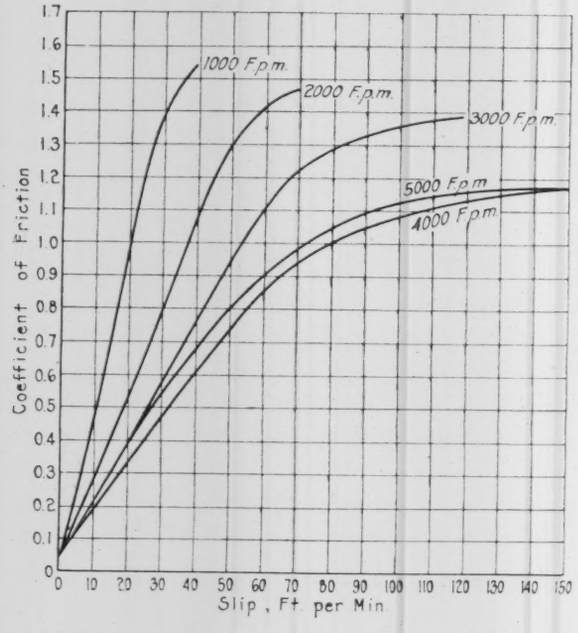

FIG. 3 COEFFICIENTS OF FRICTION AT VARYING SLIPS AND PULLEY SPEEDS (R. F. JONES)

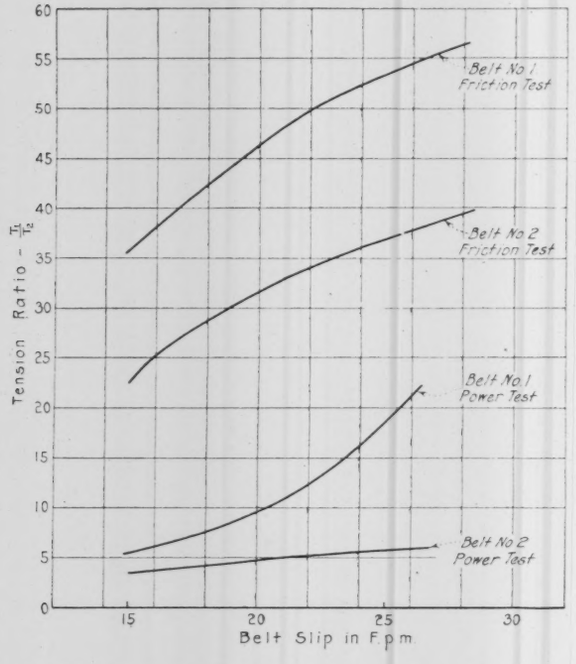

FIG. 4 CURVES INDICATING DIFFERENCE IN T_1/T_2 RATIOS AS DETERMINED BY POWER-TEST AND FRICTION-TEST METHODS (R. F. JONES)

started new with a low capacity and improved steadily with running in, until at twenty hours its transmission capacity was more than double. An even greater increase was obtained with another belt whose curves were given in Fig. 5. The increase was so great as to be remarkable, and it is included to show the wide variation in results that might be obtained on the same belt.

While the author had presented curves for a run-in leather belt in Fig. 9 of his paper, most of his comparisons were on new belts, which in the case of the textile belts was not important since they were often at their best when new, and did not usually increase much in transmission capacity with running in. However, as the writer had pointed out, this was an important factor with leather belts. To bring out the difference it might make even with friction

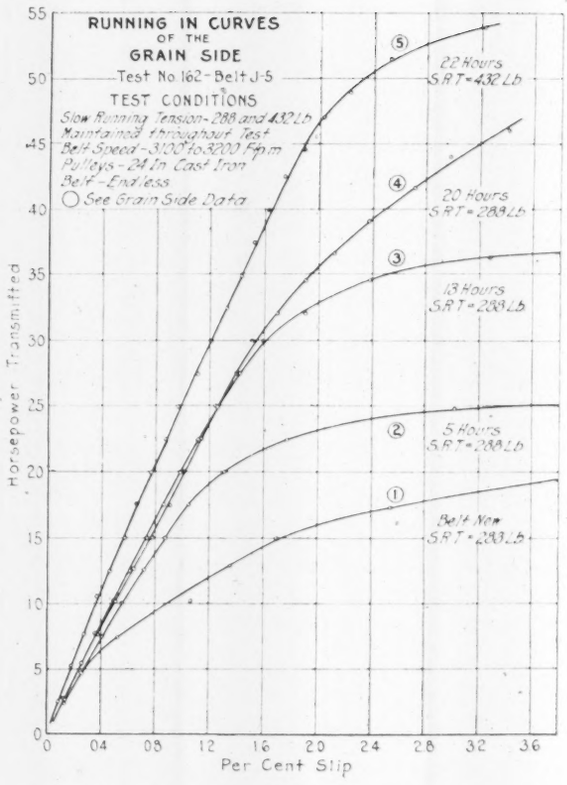
RUNNING IN CURVES OF THE GRAIN SIDE
Test No 162 - Belt J-5
TEST CONDITIONS
Slow Running Tension - 288 and 432 Lb
Maintained throughout Test
Belt Speed - 3100 to 3200 F.p.m.
Pulleys - 24 In Cast Iron
Belt - Endless
See Grain Side Data
22 Hours S.A.T. = 432 Lb
20 Hours S.A.T. = 288 Lb
13 Hours S.A.T. = 288 Lb
5 Hours S.A.T. = 288 Lb
Belt New S.A.T. = 288 Lb
Horsepower Transmitted
Per Cent Slip

FIG. 5 EFFECT OF RUN-IN ON LEATHER BELTS (R. F. JONES)

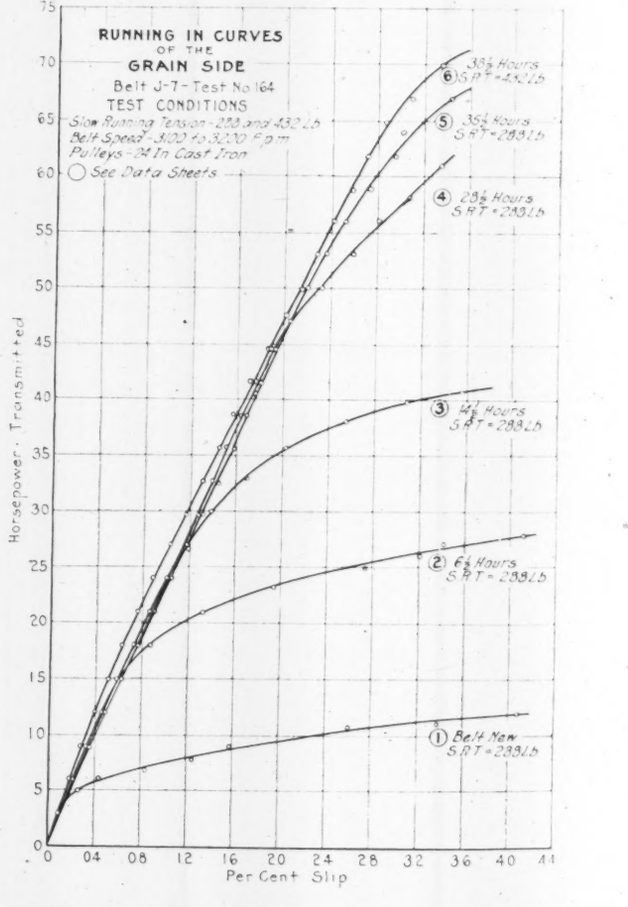
RUNNING IN CURVES OF THE GRAIN SIDE
Belt J-7 - Test No 164
TEST CONDITIONS
Slow Running Tension - 288 and 432 Lb
Belt Speed - 3100 to 3200 F.p.m.
Pulleys - 24 In Cast Iron
See Data Sheets
38½ Hours S.A.T. = 432 Lb
35½ Hours S.A.T. = 288 Lb
28½ Hours S.A.T. = 288 Lb
14½ Hours S.A.T. = 288 Lb
6½ Hours S.A.T. = 288 Lb
Belt New S.A.T. = 288 Lb
Horsepower Transmitted
Per Cent Slip

FIG. 6 EFFECT OF RUN-IN ON LEATHER BELTS (R. F. JONES)

pulley tests, he had computed curves of $\frac{T_1 - T_2}{T_1}$ for the run-in leather belt from Professor Norman's data in Fig. 9 of his paper and included them as dotted lines with his curves of Figs. 7 and 8. The high tension utilization of this leather belt was no doubt due to the ten hours' running in it received before test. A fair comparison could not be made between the dotted curve and the others because the textile belts had not been run in, except perhaps with

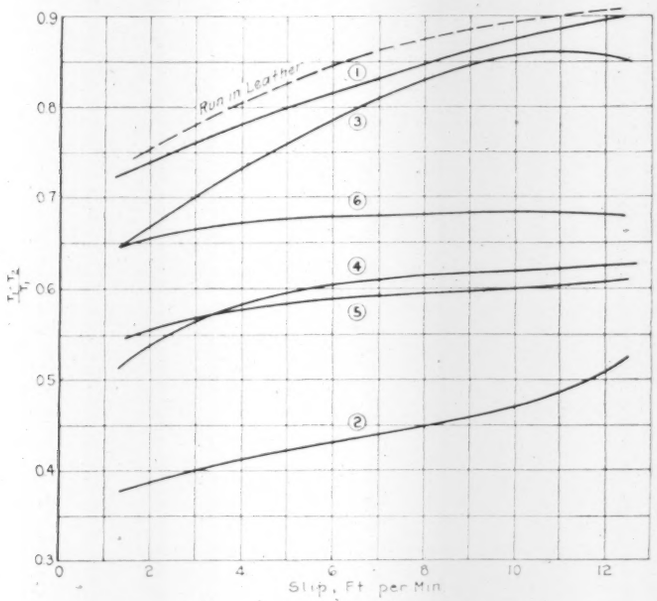

FIG. 7 EFFECT OF RUN-IN ON FRICTION-PULLEY TESTS, COMPUTED FROM PROFESSOR NORMAN'S DATA (R. F. JONES)
(Curves: 1, Special-tanned leather; 2, Oak-tanned leather; 3, Balata; 4, Rubber B; 5, Impregnated fabric; 6, Rubber A.)
(For values of $T_1 - T_2 = 35$ lb. per inch of width.)

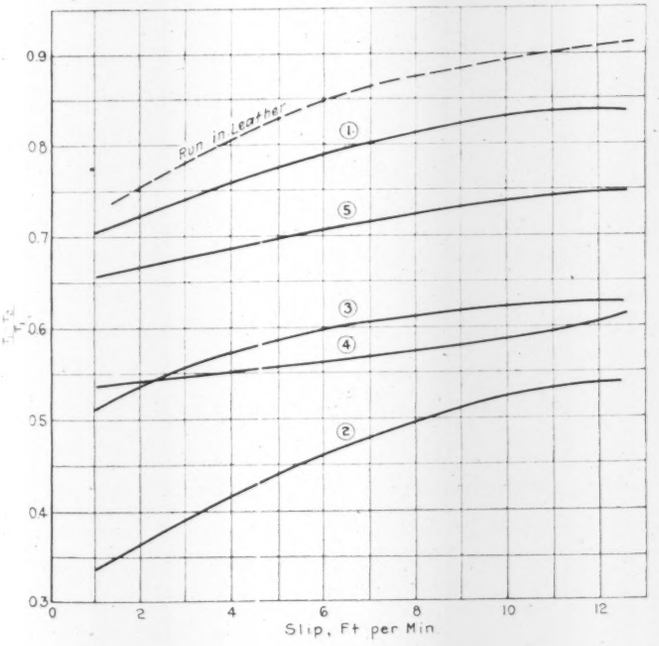

FIG. 8 EFFECT OF RUN-IN ON FRICTION-PULLEY TESTS, COMPUTED FROM PROFESSOR NORMAN'S DATA (R. F. JONES)
(Curves: 1, Special-tanned leather; 2, Oak-tanned leather; 3, Balata; 4, Rubber B; 5, Impregnated fabric; 6, Rubber A.)
(For values of $T_1 - T_2 = 25$ lb. per inch of width.)

curves 5 and 6 on Figs. 7 and 8 of the author's paper for rubber belt A, which Professor Norman said were about as good as those for the run-in rubber belt. The continuous slippage at the same point on the belt necessary with the friction-pulley test method was not equivalent to normal running in. Therefore results applicable to a running belt could not be expected.

W. F. Schaphorst[5] in his written discussion of Professor Norman's paper cited some comparative tests that were made during December, 1923, by the National Laboratories of Mechanical, Physical, and Chemical Tests in Paris, France. The tests were published in Official Report No. 41,425. Translations were available.

In these tests, he wrote, three leather belts were tested—one a patented belt of oak leather 2.76 in. wide, lined with two chrome strips each 1 in. wide. The strips were fastened by means of hollow copper rivets. This belt was known as the "combination" belt; the second was a special mineral-tanned leather belt 3 in. wide; and the third was an oak-tanned leather belt, also 3 in. wide.

The belts were tested on two polished cast-iron pulleys of 15.6 in. diameter. The pulleys were directly connected to electrical dynamometers, one serving as a motor and the other as a brake.

Throughout the tests the rim velocity of the driving pulley was maintained as closely to 4920 ft. per min. as possible.

Tables 1, 2, and 3 gave the results of the tests. The two lower lines in each table had been added so that the results could be plotted in the manner developed by the author, using his formula, $\frac{T_1 - T_2}{T_1}$. The curves of Fig. 9 showed the results of these tests graphically.

Conditions here were different from those in the tests conducted by Professor Norman in that the belts were running at nearly 5000 ft. per min., whereas Professor Norman's belts did not move. In the running tests the slip varied all the way from 34 ft. per min.

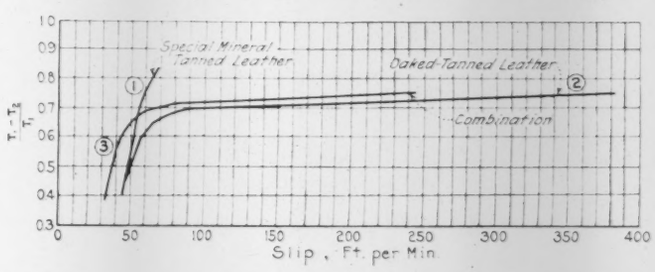

FIG 9 RESULTS OF BELTING TESTS AT THE NATIONAL LABORATORIES OF MECHANICAL, PHYSICAL, AND CHEMICAL TESTS, PARIS, FRANCE (W. F. SCHAPHORST)

to 382 ft. per min., whereas Professor Norman did not record a slip greater than 16 ft. per min. However, it was well known that a slip due to creep of 50 ft. per min. was not excessive for a belt running 5000 ft. per min.

In the French tests the "combination belt," curve 3, showed the best results up to a slip of nearly 55 ft. per min., after which the curve became almost flat.

The special mineral-tanned leather belt, curve 1, shows the best all-around results. The reason its test was not continued beyond 82 per cent was that the top of the belt became so slack that it touched the lower or tight side.

A higher effective pull was used in the French tests than in any of the tests reported by Professor Norman. For the special mineral-tanned belt, which was 3 in. wide, the pull per inch of width averaged 65 lb. for both the special mineral-tanned leather and the oak-tanned leather. The combination belt could not be computed in the same way because of its construction. The total cross-sectional area of the combination belt was 500 sq. mm., whereas that of the other two belts, the oak and the special mineral-tanned, was 382.5 sq. mm.

In the tables the total power losses were given. By deducting these total power losses from 100 per cent, the transmission efficiency of the drive might be derived. Comparing these efficiency values with the curves, it would be observed that the transmission efficiency of the special-tanned belt overtook that of the combination belt at about the point where the curves intersected at a slip of 55 ft. per min., the curves being based upon Professor Norman's formula. It was quite possible therefore that Figs. 6, 7, and 8 of the author's paper might be used to indicate power transmission efficiency as well as pulling efficiency.

One advantage of the French tests over Professor Norman's

[5] E. F. Houghton & Co., Philadelphia, Pa. Mem. A.S.M.E.

tests was that the results included creep as well as slip, whereas tests made on the apparatus used by the Ohio State University did not include creep. Referring to the curves based on the French tests, the initial rise of all of the curves was almost in a straight line, which indicated creep. As soon as the curve departed from the straight line, it was probable that slipping began. It was obvious that a curve due to creep would be a straight line so long as the strength of the belting material remained within the elastic limit.

TABLE 1 "COMBINATION" BELT

Designation	Unit												
Pull of belt on shafts	lb.	682	660	605	550	495	440	385	330	275	264	242	220	198
Tension of tight side	lb.	502	491	464	435	408	382	354	328	299	295	284	270	257
Tension of slack side	lb.	308	297	270	242	216	187	158	132	103	99	88	77	66
Total slip	%	0.70	0.70	0.72	0.72	0.74	0.78	0.82	0.88	1.02	1.06	1.22	1.64	5.00
Power losses:														
(*a*) on account of slip	%	0.70	0.70	0.72	0.72	0.74	0.78	0.82	0.88	1.02	1.06	1.22	1.64	5.00
(*b*) on account of stiffness, windage, etc.	%	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
(*c*) total	%	1.54	1.54	1.56	1.56	1.58	1.62	1.66	1.72	1.86	1.90	2.06	2.48	5.84
Sag of slack side of belt	in.	0	0.04	0.16	0.32	0.47	0.63	0.83	1.2	1.8	1.9	2.3	3.9	9
Angle of belt wrap on driving pulley	deg.	180	180	180	180	180	180	180	180	180	180	180	182	183
$\frac{T_1 - T_2}{T_1}$		0.39	0.40	0.42	0.44	0.47	0.51	0.55	0.60	0.66	0.67	0.69	0.71	0.74
Slip, ft. per min.		34	34	35	35	36	38	40	43	50	52	60	80	244

TABLE 2 SPECIAL MINERAL-TANNED LEATHER

Designation	Unit												
Pull of belt on shafts	lb.	660	605	550	495	440	385	330	275	264	242	220	198
Tension of tight side	lb.	470	442	415	387	361	332	306	277	273	260	249	238
Tension of slack side	lb.	275	249	220	194	165	136	108	81	75	64	53	42
Total slip	%	0.94	0.94	0.96	1.00	1.04	1.08	1.14	1.18	1.20	1.24	1.28	1.40
Power losses:													
(*a*) on account of slip	%	0.94	0.94	0.96	1.00	1.04	1.08	1.14	1.18	1.20	1.24	1.28	1.40
(*b*) on account of stiffness, windage, etc.	%	0.86	0.86	0.84	0.84	0.82	0.82	0.80	0.80	0.80	0.80	0.80	0.80
(*c*) total	%	1.80	1.80	1.80	1.84	1.86	1.90	1.94	1.98	2.00	2.04	2.08	2.20
Sag of slack side of belt	in.	0.24	0.24	0.27	0.32	0.35	0.39	0.59	1.06	1.18	1.57	2.36	4.5
Angle of belt wrap on driving pulley	deg.	180	180	180	180	182	182	182	182	182	182	182	182
$\frac{T_1 - T_2}{T_1}$		0.41	0.44	0.47	0.50	0.54	0.59	0.65	0.71	0.73	0.75	0.79	0.82
Slip, ft. per min.		46	46	47	49	50	52	55	57	58	60	62	68

TABLE 3 OAK-TANNED LEATHER

Designation	Unit												
Pull of belt on shafts	lb.	605	550	495	440	385	330	308	286	275	264	253	242
Tension of tight side	lb.	446	418	391	363	336	308	299	286	282	274	270	264
Tension of slack side	lb.	250	224	196	167	138	112	101	90	84	79	73	68
Total slip	%	0.98	1.02	1.06	1.12	1.20	1.36	1.50	1.80	2.40	4.40	6.20	8.00
Power losses:													
(*a*) on account of slip	%	0.98	1.02	1.06	1.12	1.30	1.46	1.50	1.80	2.40	4.40	6.20	8.00
(*b*) on account of stiffness, windage, etc.	%	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
(*c*) total	%	1.78	1.82	1.86	1.92	2.00	2.16	2.30	2.60	3.20	5.20	7.00	8.80
Sag of slack side of belt	in.	0.16	0.27	0.39	0.55	0.71	1.1	1.2	1.5	1.6	1.8	2	2.1
Angle of belt wrap on driving pulley	deg.	180	180	180	180	180	180	180	181	181	182	181	181
$\frac{T_1 - T_2}{T_1}$		0.44	0.46	0.50	0.54	0.59	0.64	0.66	0.69	0.70	0.71	0.73	0.74
Slip, ft. per min.		47	49	51	53	57	65	72	86	114	210	296	382

T. A. Bennett[6] contributed a written discussion in which he said that the paper by Professor Norman had been extremely interesting and contributed valuable research data on one phase of belt-transmission tests; yet, as had been pointed out in previous discussions, a distinction needed to be drawn between the two kinds of tests—running or power tests and friction or slip tests. Professor Norman's paper avowedly cut out running and, as a result, applied only when the belt was slipping. Furthermore, it had been ably pointed out that the difference between creep and slip should be emphasized. That brought us back to the power or running tests and to the question—where did slip start?

It was very evident from examination of the curves showing horsepower transmitted at any given speed in relation to corresponding creep and slip, as well as from the observations during such tests, that actual sliding of the belt on the pulley occurred at the point where the power line changed from an almost straight and nearly vertical line into a curve tending to the horizontal. This point, however, was not fixed, and the writer had confirmed at their plant by tests on one of their Sprague dynamometers that in any one test this point could be raised to increased values by increased initial tension and was lowered when stretch caused looseness in the belt; both properly reflecting the variation of $T_1 - T_2$, which, of course, was synonymous with the horsepower transmitted.

Mr. Bennett wished to point out here, with regard to a slide previously shown giving varying coefficients of friction, that any determinations based on the value of $T_1 - T_2$ at this point of curvature were consequently and necessarily inaccurate and fluctuating, and must vary with the tension in the belt. They could be made anything up to the maximum. It must be remembered that the basic formula, $T_1/T_2 = e^{fa}$, in which these values were inserted, was emphatically emphasized when derived as applying only for "impending slip," and was based on the coefficient of friction of rest, not of motion. There was, of course, but one value for the coefficient of rest for any two certain materials under the same testing conditions. Moreover, any values of the coefficient of friction found for points on the curve beyond the point in question would not apply in this formula, and anyway would only give values of the coefficient of friction of motion at various slipping velocities. The author's paper, as Professor Sawdon had pointed out, made tests similar to brake-band tests and obtained values for the coefficient of friction of motion at various low velocities of slipping, and it could be anticipated, as in brake bands, that the lower the speed the greater would be the coefficient.

It might safely be contended, wrote Mr. Bennett, that in practice they all were interested only in the use of belts inside the slipping point or interested in the power line up to point of curvature. If that line (the almost straight and nearly vertical part up to the point in question) could be proved to be the direct result of stretch, we could prove that it represented creep, which was conceded to be due to stretch and had therefore nothing practically to do with slip. To demonstrate this, running tests had been made at their plant on Sprague dynamometers to get the $T_1 - T_2$ values with corresponding creep for belts on which had already been found the stretch between the range of tensions existing in the tests. These were charted together and it was found that the stretch line absolutely coincided with the creep line. It was safe to conclude, therefore, that that part of the power line represented creep and that it had nothing to do with slip, as practice understood it, which occurred over the remainder of the line.

A proper definition of creep was important in belt practice. The writer had always followed the common practice of considering creep to be the difference between the number of revolutions of the driver and the driven pulleys, which gave a direct basis for determining just what speed the driven shaft would have. This difference in revolutions was conceded as due to the change of speed between the tight and loose sides of the running belt, which in turn was conceded to be due to the stretch of the belt caused by the difference in tensions. Selby Haar in 1911 had presented a paper illustrating the variation in speed throughout the complete circuit as shown by experiments by Fieber, Kammerer, and others, and had advanced some valuable theories. It was evident that the tension was a maximum as the belt went on to the driver, and as a result the stretch and therefore the speed was also a maximum. Since the tension here was a maximum, the normal pressure was a maximum and the belt was least apt to slip at this part of its arc of contact on the driver; but, as the belt revolved with the driver, the tension decreased, and therefore the normal pressure decreased until the tendency of the belt to contract overcame its grip on the driver and the belt crept backward. It seemed correct to assume that the contacting surfaces of the belt and pulley moved together at the same speed until this creep began, and it had been roughly found by incomplete measurements that this condition did exist for the first 45 to 90 degrees of the arc of contact. This led to two rules which would simplify what tended

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to become complex: (1) The "belt speed" could be defined as that of the surface of the driver, and (2) this speed was coincident with the maximum tension and speed in the belt. These rules gave a fixed basis upon which to figure the horsepower and the maximum tension and stretch in the belt.

Conversely, on the driven pulley the belt went on under minimum tension, and therefore the normal pressure was minimum and the grip on pulley, minimum. As the belt revolved with the drive pulley it began to grip and drive it, resulting in increased tension with consequent, stretch, which caused the belt to creep forward until the normal pressure due to increasing tension caused a grip greater than the creep could overcome, and then the two moved together at the same speed (inside overload or slipping conditions). It would seem that this slack or stretch held back in the belt by its grip on the pulley, would suddenly come out as the belt was leaving the pulley. The rough determinations so far made indicated this, but it would seem well to demonstrate it by more careful experiments, which it was expected would be made. It seemed correct, however, to assume that the belt and driven pulley moved at same speed over a small arc (perhaps up to 30 deg.) just near the end of contact.

By this analysis on both pulleys it was deduced that the "belt speed" was the same as the circumferential speed of the driver, while the circumferential speed of the driven was less by the stretch of the belt between this small arc on the driven and the point of contacting with the driver. Thus creep was again demonstrated as due to stretch, and could be measured by the common rule of practice to be the difference in revolutions (or circumferential speeds) of the driver and driven. This should not be difficult to show by test, and it was planned to run such tests.

Mr. Bennett added a word of caution against confusing creep with loss of power or "transmitting capacity" (a term recently much used).

In the oral discussion at the session at which Professor Norman's paper was presented, R. R. Tatnall[7] stated that in the laboratories of J. E. Rhoads & Sons tests on leather belting had been carried out for the last five years with two machines, one a friction pulley machine similar to Professor Norman's, and one similar to that described by Professor Jones in the written discussion. Some of the results obtained had been presented by Professor Jones in the written discussion. Mr. Tatnall discussed some tests subsequent to those he had communicated to Professor Jones. Testing a rubber belt by the friction-pulley method, he had found a practically constant value of the ratio $\frac{T_1}{T_2}$ for various values of slip. The coefficient of friction also seemed to be independent of the slip. The rubber belt seemed thus to behave quite otherwise than did a leather belt. In a recent series of measurements with the friction-pulley machine, Mr. Tatnall found that the initial tension at which the belt was set before the pulley began to rotate had quite an effect on the results obtained. With initial tensions starting at 100 lb. and going through the series 80, 60, 40, 10, 140, and finally 100 lb., they showed a first ratio $\frac{T_1}{T_2}$ of 18, and a final ratio of 28 with the same initial tension of 100 lb. The speaker thought that either the pulley was warming up during the test, or the belt was losing grease, or that there was some kind of progressive change going on which made the values obtained by this method a function both of initial tension and of other unknown factors. In the light of this experience Mr. Tatnall concluded that the friction-pulley method was not applicable to belting when transmitting power.

Selby Haar[8] pointed out that the experiments carried out by Professor Kammerer, of Germany, had been brought before the Society, in a paper by Mr. Haar on belt driving printed in the Journal of the Society for December, 1910.

AUTHOR'S CLOSURE

The author, in closing, wrote that he felt the need of careful analysis of the wealth of new material submitted in the discussion. His own purpose had been perfectly simple: to show the influence of slip on the tension ratio and transmissive power of belts. Information on this subject was necessary. Some published experiments had created the impression that slip was almost fatal to the transmissive power of fabric belts, while it increased the transmissive power of leather belts almost indefinitely. The influence of slip in the case of a running belt was, however, inextricably entangled with the influences of belt speed, centrifugal force, angle of contact, elasticity of material, etc. The only way to disentangle slip from these other influences was to use a stationary belt on a slowly revolving pulley, as the author had done. If the slip was not great enough to cause heating and deterioration of the belt, this method seemed quite satisfactory. The results obtained seemed clear and consistent with other findings. It was found that leather belts, at least when run in, showed a very gratifying increase of tension ratio and pulling efficiency with slip. A running-in period was, however, necessary to develop the pulling power of oak-tanned leather belts, although it did not seem to be necessary for certain kinds of mineral-tanned belts. Nevertheless, fabric belts showed some creditable pulling efficiencies, too—better in fact than those of new oak-tanned leather belts—and they showed them from the very start. Nor did a certain period of running impair this efficiency.

No evidence had been offered in the discussion to indicate that these conclusions regarding the influence of slip were not perfectly justified. If results somewhat different in detail had been obtained by this method in more casual experiments by other investigators, this might in part depend on greater slips and heating of the belt; or it might depend on the fact that these tests had not been replotted to refer to constant effective pulls. This would have to be done in order to get results that could be compared with those of the author.

The allegation had, however, been made that real slip was less of a factor in running belts than "creep." By creep was understood a motion between belt and pulley caused by a stretching and a contraction of the belt as it passed over the pulley. If this meant real motion between the belt and the pulley, as it undoubtedly did, it was difficult to understand why it should, as slip, influence the belt adhesion in a different way from uniform slip of the same speed. The only points of difference were, (1) that the average slip over the pulley might in creep be only half of the total measured slip, or even less; (2) that the slip might develop particularly over a small angle of contact, and hence not be very effective; and (3) that at higher speeds the effect of slip on measured transmissive power might be counterbalanced by the opposing effects of centrifugal force on contact pressure and of speed on angle of real contact. It was on account of these countervailing influences that the tests with a running belt might give results either deceptive or at least not generally applicable as far as slip was concerned Thus Mr. Jones gave in his Fig. 2 certain curves showing $T_1 - T_2$ against percentage of slip. It was to be regretted that these curves did not give T_1/T_2 or $(T_1 - T_2)/T_1$ forstated tensions, as the author's curves did. As it was, they were difficult to interpret, and the absence of the original test points made conclusions especially precarious. What they seemed to show was only that at 4000 to 5000 ft. per min. the belt tension was not sufficient to permit an effective pull of more than some 400 lb. without undue slip. At lower speeds, i.e., lower centrifugal force, a higher effective pull could be transmitted without such slip. That the curves coincided at lower effective pulls, was simply due to the fact that at these speeds the influences of slip, centrifugal force, angle through which slip occurred, etc., counterbalanced each other so as to give approximately equal percentage slip for various speeds, at the same effective pull. The conclusion from Mr. Jones' curves would be that transmissive power and coefficient of friction were independent of speed in the whole creep region. This was in direct opposition to the conclusions drawn by Barth from the tests of Lewis, and by German practice from the tests of Kammerer and others. These conclusions all were to the effect that effective pull or coefficient of friction increased with the speed, and this was most easily explained by the assumption that the transmissive force increased with the absolute speed of slip rather than with the percentage. Mr. Jones' curves were therefore certainly not generally applicable. It was very gratifying to hear that the organization represented by Mr. Bennett planned further tests to clear up this matter.

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New Boiler Equipment at the Interborough Rapid Transit Co.'s Fifty-Ninth Street Power Station

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THE boiler room of the Fifty-Ninth Street Power Station of the Interborough Rapid Transit Company in New York City, since its initial completion in 1905, has reflected the development which has taken place in coal-burning and boiler equipment in a very graphic manner. The original equipment consisted of 600-hp. boilers equipped with hand-fired grates. These boilers could not be operated much in excess of 100 per cent of rating, and in connection with the Manhattan-type engines, which were installed in the engine room, each boiler could produce about 1000 kw.

Soon after the station was completed the original hand-fired grates where replaced by Roney automatic stokers, which reduced the labor costs, increased the efficiency and enabled the boilers to be operated at a slightly higher capacity. In 1910 it was necessary to obtain additional boiler capacity, so the idea was conceived of installing an additional Roney stoker under the rear of the boilers to supplement the stokers which had been previously installed under the front of the boilers. It is interesting to note that when this proposed addition was discussed with various engineers, and they were told that the boilers were expected to operate at 200 per cent of rating after the alteration, they expressed grave doubts as to whether it would be possible to operate the boilers at such a high overload. However, eighteen of these "double" Roneys were installed, and they gave the required increase in capacity as expected.

At 200 per cent of boiler rating and with the increased economy obtained in the engine room by adding low-pressure turbine units with surface condensers to the original engines, the capacity per boiler became approximately 2200 kw.

The next increase in boiler capacity was obtained by substituting underfeed stokers in place of the remaining "single" Roney stokers and six of the "double" stokers, thus leaving twelve double Roney stokers in use in 1919. Up to this time no additional boilers had been installed, although the capacity of the station had been more than doubled over the original installation.

The installation of the underfeed stokers was made in groups which varied in design of setting and stoker, and in size of stoker. With induced draft, 250 per cent of rating is a fair average of the capacity of the stokers so equipped. These stokers were installed mainly in connection with three 35,000-kw. turbines, and for this reason the boilers feeding these turbines were also provided with superheaters. By supplying steam to these turbines and by being equipped with superheaters each boiler was raised in capacity to approximately 3000 kw.

Due to the recent purchase of additional subway cars, it became necessary to again increase the boiler-room capacity at the Fifty-Ninth Street Power Station. This could have been obtained by substituting underfeed stokers for the remaining twelve double Roney stokers. However, in view of recent developments in fuel-burning equipment and the fact that the boilers over the Roney stokers were set rather low, this was not desirable. Another objection to increasing the capacity of the old boilers was that these boilers are in the saturated-steam section of the station, and therefore superheaters could not be installed and the resulting economy realized.

The Fifty-Ninth Street boiler room was originally designed to house six sections of boilers, each section consisting of twelve 600-hp. boilers discharging into a common stack. However, only five sections and five stacks were installed. All these boilers are on one elevation at 17 ft. 9 in., while economizers were installed on a separate floor at an elevation of 54 ft. 9 in.

It was finally decided to obtain the additional capacity by installing four new boilers and stokers in a portion of the vacant section at the west end of the boiler room. As stated before, this section like the others was originally designed to house twelve 600-hp. boilers set in batteries of two each. As a result of this the existing building columns prevented the installation of new boilers and stokers any wider than the old 600-hp. boilers. Considerable headroom was obtained by removing the economizer floor at the elevation 54 ft. 9 in. The new installation is designed on the basis of ultimately installing four more boilers in the remaining space, so that the final number of boilers in this stack section will be eight. The other four of the twelve available boiler bays are to be used for blowers and the possible installation of economizers or air heaters.

The new boilers operating at normal high load of 300 per cent of rating and supplying steam to the 35,000-kw. turbines now in place will develop a capacity of approximately 7000 kw. At 350 per cent of rating and with the same water rate they would have a capacity of 8200 kw. each. Since only eight of the new boilers are proposed for the space occupied by twelve of the old type, the actual ratio of capacity of new and old equipment per stack section would be 65,600 kw. to 36,000 kw. With the addition of turbines with stage heating the capacity of the new boiler equipment per stack section would be approximately double that of the old underfeed stoker and turbine equipment. Thus, for the same boiler-room space the power-plant capacity would be increased about six times over that obtained from the hand-fired furnaces and the reciprocating-engine units.

In view of the fact that the old economizer floor at elevation 54 ft. 9 in. was removed in order to provide headroom for these boilers, new methods of bracing the building columns situated between each two adjacent boilers had to be provided. This was accomplished by adding diagonal eccentric bracing at some points, while horizontal bracing girders were provided at other places. The existing columns required no alteration except between the 54-ft. 9-in. and the 69-ft. 3-in. elevations, where it was necessary to strengthen them by adding additional flange plates.

The boiler which was selected is of the horizontal longitudinal drum, inclined-tube, vertical-header type, and is 21 sections wide and 24 tubes high, with three longitudinal drums, the tubes being 20 ft. in length and 4 in. in diameter, giving a total heating surface of 11,400 sq. ft. The old 600-hp. boilers were 21 sections wide and 14 tubes high, while the tubes were 18 ft. long. These new boilers are the highest which have ever been installed over a stoker. However, in view of the increasing length of stokers this is a logical development in order to retain the proper ratio between stoker area and boiler-heating-surface area. It is interesting to note that the ratio between the boiler surface and the grate surface in the case of this new installation is almost exactly the same as it is in the case of the old 14-tube-high boilers and the 17-tuyere stokers.

The superheater is of the interdeck type and is located between the sixth and seventh rows of boiler tubes from the bottom. As shown in Fig. 1, the entire length of the lower six rows of tubes is exposed to the fire, and the baffling begins at a point above the superheater.

In order to obtain a uniform feedwater supply to all three of the drums and thus prevent any great difference in the water level between them, the individual drum checks are omitted and the feed pipes to each drum are carried to a relatively large-diameter short header across the front of the drums. The water

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is fed to this header at two points through non-return stop valves and hand-regulating valves. The arrangement was made suitable for automatic feedwater regulators though these have not yet been installed.

The stokers are of the Taylor HC7 type, seven retorts wide and 37 tuyeres long, equipped with double-roll clinker grinders. These stokers have one set of rams which feed the coal into the stoker. The fuel is then worked down the grate by means of a series of six pushers which may be seen in Fig. 1. Thus the fuel is continuously agitated and forced into the grinder pit. Each stoker is driven by means of a d.c. variable-speed motor through a lineshaft placed under the front of the stoker. The grinder rolls are also driven from this lineshaft. The drive of each stoker is independent. However, each stoker motor is of sufficient capacity to drive two stokers in an emergency, which can be done by throwing in a clutch in the lineshaft. In addition to the variable-speed motor, further flexibility can be obtained by means of the two-speed device with which each one of the two power boxes of each stoker is equipped.

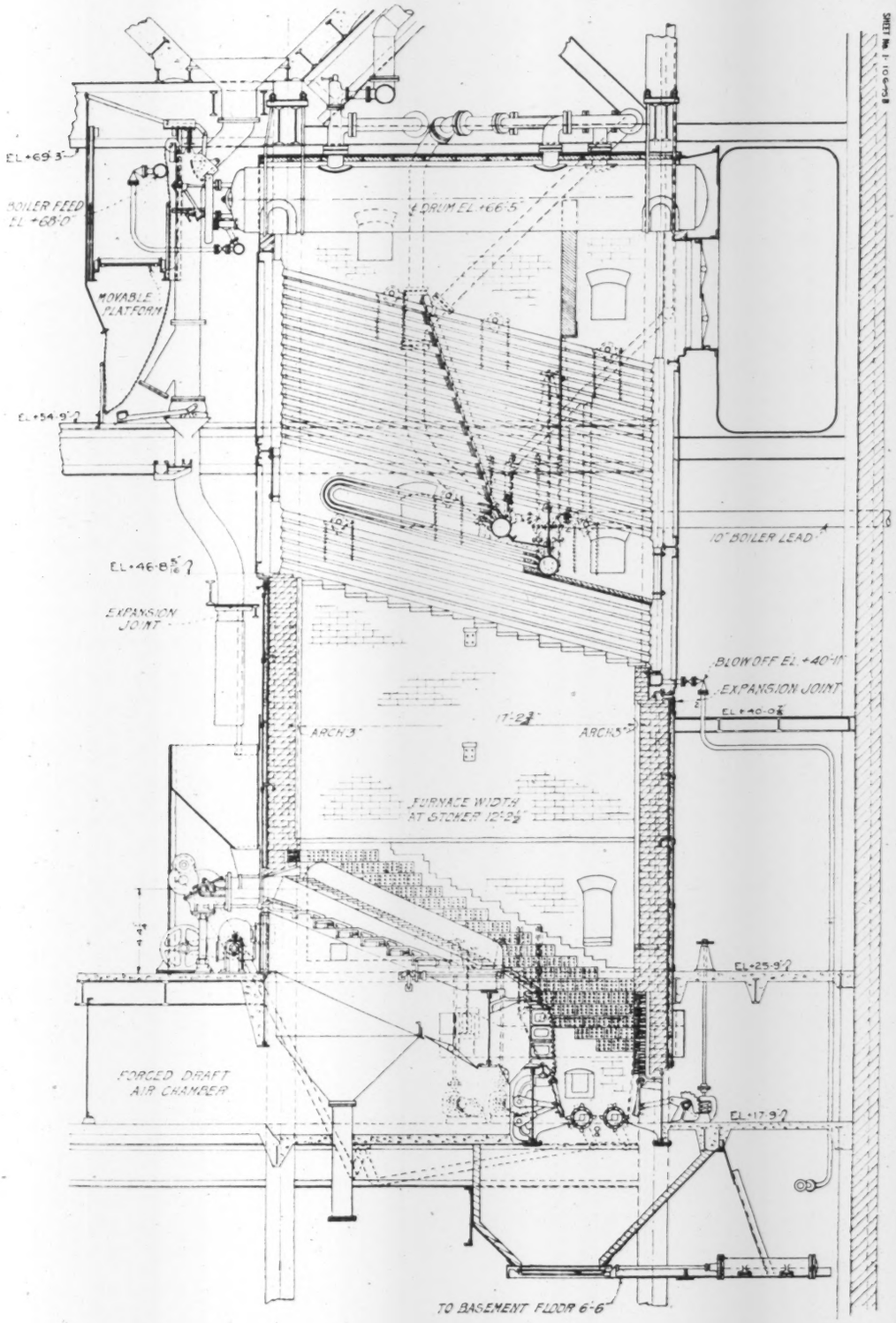


FIG. 1 CROSS-SECTION OF BOILER, STOKER, AND FURNACE

Due to the space limitations between the boiler, stoker, and the building columns, adequate protection of the building steel presented a difficult problem in connection with the design of the furnace. However, the ultimate design provided for an exposure of one or two sides of each building column and an air space around the remaining sides.

The size of the stoker selected necessitated vertical walls on all four sides of the furnace. A slight arch or outward bulge was given to the walls above the stoker and up to the boiler tubes. The walls were also tied into the sheathing framing at intervals as shown in Fig. 1. Perforated Bernitz blocks were installed in all four walls up to the fire line. The girders at the elevation of the old economizer floor running between the columns at the front of the boiler to the columns at the rear were retained in order to provide the necessary bracing. These girders were put to a further use by allowing them to carry all of the furnace walls above this point. All walls were made up of $^1/_8$-in. sheathing, a $2^1/_2$-in. layer of Sil-o-cel insulation which was carried on the sheathing framing at 3-ft. intervals; a layer of asbestos millboard, and the remainder of firebrick which varied from $13^1/_2$ in. to $18^1/_2$ in. in the case of the side walls and from 19 in. to 24 in. in the case of the front and rear walls. The purpose of the asbestos millboard was to facilitate the erection of the Sil-o-cel and prevent a bond between the Sil-o-cel and the firebrick.

The entire setting including the roof over the boiler is enclosed in sheathing. In order to avoid interference with the column bracing a special type of sheathing framing and joint is used. The angle-iron framing is placed inside of the sheathing. This framing is punched with square holes so that with the use of square-shanked bolts placed with the nuts on the outside, the plates can be removed and replaced after the settings have been completed. The plates were dimensioned so that a space of sufficient width was left between adjacent plates for the bolts to pass through and thus it was not necessary to punch the plates. In order to close this space and also to form a bearing for the bolt nuts, a strap is placed on the

outside overlapping the sheathing plates. A high degree of air tightness is obtained by placing an asbestos-tape gasket between the strap and the sheathing plates.

In view of the fact that the upper portion of the sheathing is supported on a girder it is necessary to provide an expansion joint. This expansion joint is formed from two heavy copper strips clamped against the upper and lower sheathing plates so that the sheathing is free to slide back and forth between the copper strips.

Due to the existing building columns, it is necessary to place the boilers in groups of two with a passageway on only one side. However, as far as the settings are concerned, a space of about 3 in. is left between each pair of boilers, so that they are entirely independent of each other.

In future installations it may be preferable to install one boiler instead of each battery omitting the center or adjacent walls, if a satisfactory method of protecting the center building columns can be devised. For the present installation this did not work out advantageously from an operating standpoint.

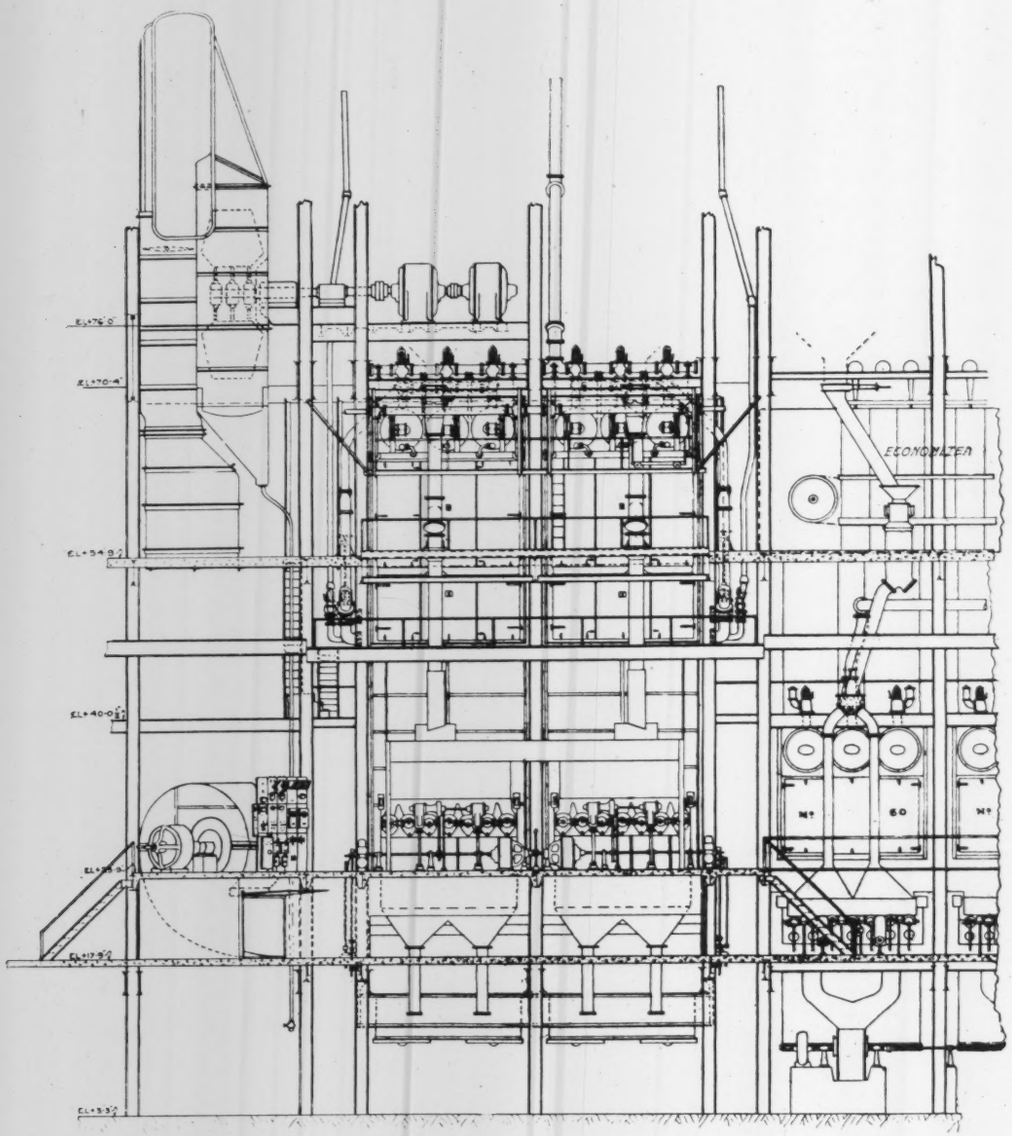


FIG. 2 VIEW OF TWO OF THE NEW BOILERS, SHOWING ONE OF THE OLD BOILERS AT RIGHT

Forced draft for each battery of boilers is furnished by one centrifugal single-inlet blower of the backward-curved vane type. This blower has a capacity of 120,000 cu. ft. of air per minute at 7 in. static discharge pressure. It is directly driven by a 250-hp. slip-ring variable-speed motor. As shown in Fig. 2, the blower is arranged for a down-horizontal discharge. The discharge is through a swinging damper, balanced to open or close with the pressure, and into an air duct formed between the original and new boiler-room floors. A partition is placed in this air duct so that the blower discharge can be confined to one battery. Normally it is expected to operate with some panels of this partition removed so that one blower or two blowers can be used for the four boilers, depending on the load. An extension of the installation would simply extend this duct for eight or more boilers. The blowers are located conveniently for connection to an air heater and the outboard bearing is arranged for water cooling. Their capacity is sufficient for air heating up to about 275 deg. fahr. The control for the forced-draft motor is placed at a control board which serves two boilers. The forced-draft dampers of each stoker are operated by motors arranged for push-button control from the control-board.

The flue gases from each pair of boilers discharge into a common flue which passes to the induced-draft fan. By means of a bypass damper, the gases may pass directly to the stack. The induced draft fans are of the cindervane type. The capacity of each fan is 250,000 cu. ft. per min. against a total head of 3.0 in. of water when handling gases at a temperature of 700 deg. fahr. Two squirrel-cage motors are installed on the same shaft in connection with each fan. One motor is of 715 hp. capacity and runs at a speed of 180 r.p.m., while the other motor is of 350 hp. capacity and operates at a speed of 240 r.p.m. Only one motor is used at a time, while the other runs idle. The purpose of the two motors is to provide spare equipment and at the same time furnish simple and economical speed control instead of using an uneconomical or expensive variable-speed motor. The induced-draft fan motors are started and stopped from the control board on the boiler-room floor. The boiler-outlet dampers and the induced-draft fan bypass damper are motor-operated and are controlled by push buttons on the control board. In addition to the remote hand control for the boiler-outlet dampers an automatic control is provided for these dampers which maintains a constant suction pressure in the furnace.

A new stack was built for these boilers, and was placed on a structural-steel platform over the center of the firing aisle. This platform was a part of the original building structure. The five old stacks are of the same height but the internal diameter is only 15 ft. at the top and 18 ft. at the base. The use of a stack with less taper and a thinner wall made it possible to install one of larger diameter on the existing platform. The stack was designed to receive the gases from eight boilers similar to the four installed and is 162 ft. 11 in. high above its base and 217 ft. $3\frac{1}{16}$ in. high above the boiler-room floor. The internal diameter is 20 ft. $10\frac{3}{8}$ in. at the base and 20 ft., 0 in. at the top. The thickness of the wall is $18\frac{1}{8}$ in. at the base and $10\frac{5}{8}$ in. at the top.

Boiler ratings of 180 per cent can be obtained on natural draft while ratings up to 250 per cent can be obtained by operating the

induced-draft fans with the smaller motors. For ratings above 250 per cent it is necessary to use the larger of the induced-draft fan motors.

In addition to the various hand and automatic controls which are centralized at the control boards, a Bailey boiler meter is provided for each boiler, together with draft gages indicating the draft at various points. In order to obtain a record as to the condition of the boiler and superheater surface, recording thermometers give the temperatures of the flue gases and the steam leaving the superheater.

Economizers or air heaters were not installed in connection with these boilers. However, space was left where such equipment can be installed in the future. As before noted, the forced-draft blowers are of sufficient capacity and are suitably arranged for air heaters. To carry normal high load with air heaters or economizers added, with the induced-draft fans now installed, the present boiler baffling will need to be changed. With this in view the baffle between the second and third passes of the boilers was made of iron plates that can be easily removed in sections.

After the installation was completed one of the units was selected on which extensive boiler tests were run. All of these tests were conducted in accordance with the A.S.M.E. test code. Coal and water quantities were determined by means of calibrated scales. The results are given in Table 2, while the principal data are plotted in Fig. 4. The method of taking these data requires no explanation, with the possible exception of the item giving the percentage of combustible in the ash. Due to the large storage capacity of the grinder pit, it was impossible to obtain ash samples which would be representative of each test. In view of this difficulty, samples were taken during each test, but instead of using these samples for their respective tests, the results of all the samples, which varied but little, were averaged and applied to all the tests.

The equipment with its accessories is distributed vertically over five floor levels, and some readings had to be taken on each floor. The work of taking observations was reduced considerably by building a shack on the third-floor level and bringing all pressure, draft, temperature, and CO_2 readings above the operating-room floor to this shack. This was accomplished by means of high-pressure copper tubing for the steam pressures. There was also a supply of high-pressure air provided for blowing out gas lines and for assisting in taking of gas samples. Draft gages were connected to the boiler from the shack with small copper tubing, while the numerous temperatures taken were observed in the shack by using thermocouples and long leads. The temperatures were recorded by use of an automatic Leeds & Northrup 8-point recorder and two manual L. & N. indicators connected to 10-point switches. Thus by means of interchecks between pyrometers, steam-gage readings, and references to steam tables a close watch was continually maintained on all instrument accuracy.

The good lighting of the shack and better environment in general contributed much toward the gathering of accurate data with a minimum force of intelligent assistants.

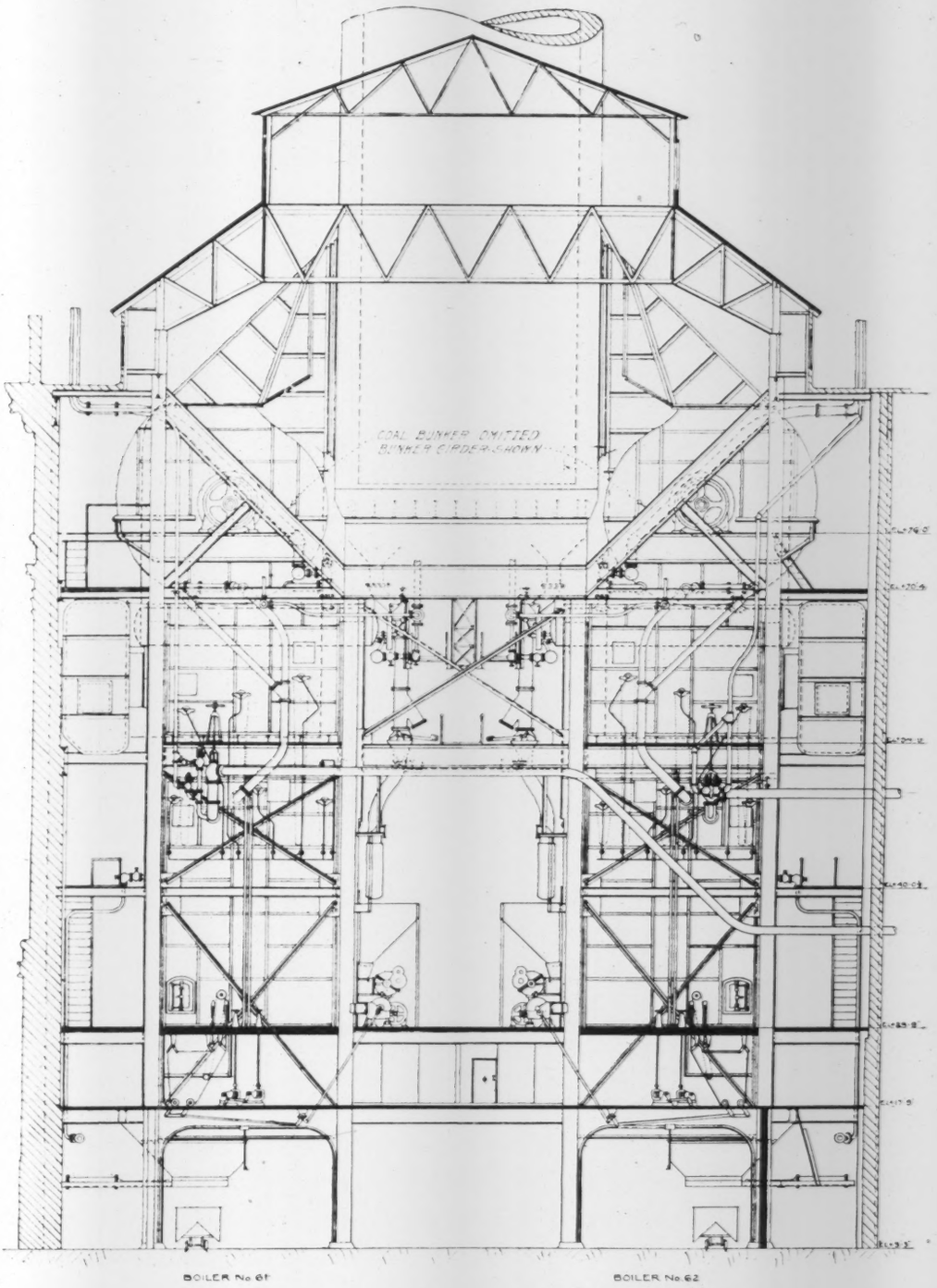


FIG. 3 CROSS-SECTION OF BOILER ROOM AT THE LOCATION OF THE NEW BOILERS

In addition to the efficiency tests a capacity test was run at 400 per cent of rating for one hour. Apparently this rating could have been increased and carried for a longer period as far as the stoker and boiler were concerned. However, it is not intended to operate these units much in excess of 300 per cent of rating during normal operation.

The tests show a boiler efficiency fully up to expectations. Some

TABLE 1 PRINCIPAL DATA COVERING BOILERS NOS. 61–64, INCLUSIVE, FIFTY-NINTH STREET POWER STATION

Boilers and Superheaters:	
Mfr. of boilers	B. & W.
Horsepower	1140
Heating surface, sq. ft.	11,400
No. of tubes wide	21
No. of tubes high	24
Length of tubes	20 ft.
Diam. of tubes, outside	4 in.
No. of drums	3
Height of bottom of front header above floor	20 ft. 11 5/16 in.
Height of center line of drums above floor	40 ft. 8 in.
Heating surface per sq. ft. of grate	53.8 sq. ft.
Heating surface per cu. ft. of furnace	3.07 sq. ft.
Area of superheaters, sq. ft.	1485
No. of rows of boiler tubes below superheater	6
Stokers and Furnaces:	
Mfr. of stokers	Am. Engrg. Co.
No. of retorts	7
No. of tuyeres long	37
Width of furnace	12 ft. 2 1/2 in.
Depth of furnace	17 ft. 2 3/4 in.
Projected grate area, sq. ft.	212
Area of grate per sq. ft. H.S.	0.0185 sq. ft.
Area of grate per b.hp.	0.185 sq. ft.
Area of grate per cu. ft. furnace volume	0.057
Average height of tubes above grate	17 ft. 6 in.
Total volume of furnace above grate	3710 cu. ft.
Cu. ft. of furnace per sq. ft. grate	17.5
Cu. ft. of furnace per sq. ft. H.S.	0.326
Cu. ft. of furnace per b.hp. rated	3.26

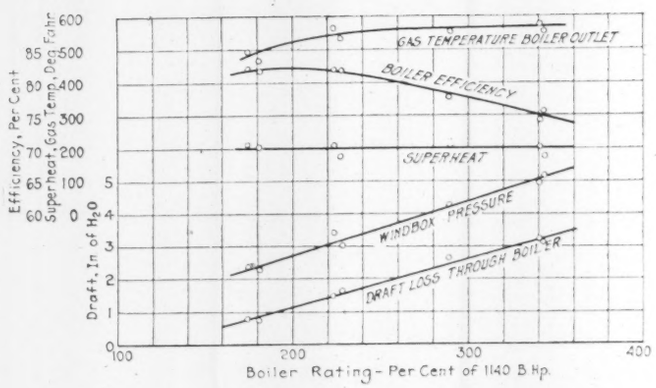


FIG. 4 TEST RESULTS

TABLE 2 SUMMARY OF RESULTS—TESTS ON 1140 HP. BOILER—I. R. T. CO., FIFTY-NINTH STREET POWER STATION

No.	ITEM	TEST NO. (5)	(7)	(8)	(9)	(12)	(14)	(15)
	Rating, Boiler—per cent of 1140 Hp...	180.8	174.2	223.2	227.8	343.5	288.7	340.2
	Fuel—Proximate Analysis—Dry							
1	Volatile matter, per cent	16.12	16.10	16.41	17.19	16.31	15.78	15.91
2	Fixed carbon, per cent	77.04	77.53	76.92	76.04	76.69	77.24	77.83
3	Ash, per cent	6.84	6.37	6.67	6.77	7.00	6.98	6.26
4	Moisture (as fired), per cent	2.93	3.86	3.43	3.00	3.20	2.74	2.87
5	Heat value (as fired), B.t.u. per lb.	14,158	14,150	14,212	14,215	14,149	14,236	14,331
6	Heat value (dry), B.t.u. per lb.	14,584	14,718	14,716	14,655	14,617	14,638	14,755
	Fuel—Ultimate Analysis—Dry							
7	Carbon, per cent	84.46	84.69	84.84	84.67	84.69	84.05	83.46
8	Hydrogen, per cent	5.12	4.58	5.22	5.53	4.74	5.32	5.76
9	Oxygen, per cent	0.82	1.60	0.59	0.25	0.75	1.11	1.89
10	Nitrogen, per cent	1.22	1.27	1.29	1.28	1.37	1.27	1.21
11	Sulphur, per cent	1.54	1.49	1.39	1.50	1.45	1.27	1.42
12	Ash, per cent	6.84	6.37	6.67	6.77	7.00	6.98	6.26
	Gas Analysis—Boiler Outlet							
13	Carbon dioxide, per cent	14.62	14.15	14.65	14.03	14.28	13.38	13.59
14	Carbon monoxide, per cent	0.24	0.11	0.27	0.16	0.16	0.16	0.48
15	Oxygen, per cent	3.98	4.88	4.36	5.05	4.64	5.56	4.81
16	Nitrogen, per cent	81.16	80.86	80.72	80.76	80.92	80.90	81.12
17	Excess air, coefficient	1.221	1.290	1.210	1.260	1.272	1.327	1.265
	Pressures and Drafts							
18	Steam pressure gage S.H. out., lb. per sq. in.	230.4	234.5	235.8	227.8	234.9	232.0	234.8
19	Air pressure ashpit zone, in. H_2O	2.26	2.38	3.44	3.08	5.16	4.30	4.93
20	Draft in furnace, in. H_2O	0.033	0.033	0.055	0.065	0.147	0.086	0.14
21	Draft in boiler outlet, in. H_2O	0.775	0.79	1.60	1.704	3.34	2.76	3.38
22	Draft drop, in. H_2O	0.742	0.757	1.545	1.639	3.193	2.674	3.24
	Temperatures							
23	Steam temp. S.H. out., deg. fahr.	602.5	613.7	609.8	575.6	579.6	610.6	604.2
24	Superheat, deg. fahr.	203.2	213.0	208.6	177.2	178.7	210.6	203.4
25	Temp. of air for combustion, deg. fahr.	82.7	80.6	81.0	73.3	73.0	87.0	82.2
26	Temp. of gases blr. out., deg. fahr.	475.5	495.1	566.3	539.4	551.6	552.3	573.7
27	Temp. of feedwater, deg. fahr.	184.5	187.4	187.1	190.4	188.9	189.8	189.4
	Hourly Quantities							
28	Duration of test, hr.	12	12	12	10	8	7	4
29	Dry fuel per hour, lb.	5784.1	5498.5	7034.2	7230.2	11,848.9	9667.4	11,834.5
30	Dry fuel per sq. ft. of grate per hour, lb.	27.28	25.94	33.18	34.10	55.89	45.60	55.82
31	Equivalent evap. per hr., lb.	71,135	68,504	87,781	89,596	135,113	113,572	133,807
	Refuse							
32	Combustible in the refuse,[1] per cent	6.00	6.00	6.00	6.00	6.00	6.00	6.00
	Evaporation							
33	Actual evap. per lb. fuel (dry), lb.	10.267	10.380	10.412	10.518	9.653	9.819	9.479
34	Equiv. evap. per lb. fuel (dry), lb.	12.298	12.459	12.479	12.392	11.403	11.748	11.307
35	Boiler rating—per cent of 1140 hp.	180.8	174.2	223.2	227.8	343.5	288.7	340.2
36	Efficiency of boiler, superheater, furnace and grate, per cent	81.82	82.14	82.28	82.05	75.70	77.88	74.36
	Heat Balance							
37	Heat absorbed by water, per cent	81.82	82.14	82.28	82.05	75.70	77.88	74.36
38	Heat loss due to moisture in fuel, per cent	0.25	0.34	0.31	0.27	0.29	0.24	0.25
39	Heat loss due to moisture from burning of H_2O per cent	3.87	3.46	4.05	4.29	3.70	4.14	4.46
40	Heat loss due to moisture in the air, per cent	0.26	0.18	0.22	0.10	0.15	0.19	0.36
41	Heat loss due to dry chimney gases, per cent	9.37	10.24	11.49	11.61	11.76	12.27	12.05
42	Heat loss due to incomp. burning of C., per cent	0.94	0.45	1.05	0.66	0.63	0.69	1.95
43	Heat loss due to combustible in refuse, per cent	0.43	0.40	0.41	0.43	0.44	0.45	0.39
44	Radiation and losses unaccounted for, per cent	3.06	2.79	0.19	0.59	7.33	4.14	6.18

[1] Owing to the difficulty of obtaining representative ash samples during each test due to the large amount of ash in the grinder pit, 6 per cent was taken throughout all the tests, for the amount of combustible in the refuse, which was based on a great many samples taken at random.

of the test results, however, need further explanation. Thus the low temperature of the gases at the boiler outlet for the high loadings is apparently subject to question. This is probably due to some air leakage in the last pass, where the suction pressure is quite high during the high-rating tests. The large unaccounted-for losses shown at the higher ratings would substantiate this view. If the outlet-gas temperatures were assumed to vary directly with the load the temperature for test No. 12 would be approximately 690 deg. fahr. This would still leave a fairly high percentage of unaccounted-for losses, taking into consideration the probable heat radiated.

Referring to the test curves, Fig. 4, it will be noted that the draft loss through the boiler varied directly with the load. It was anticipated that at the higher ratings this curve would show an upward curvature. It is probable that the even velocity flow of the gases provided for by the baffle design eliminated this increasing drop for the loads tested, and that the increasing stack effect in the high first pass tends to offset the draft loss at the high ratings.

In addition to the data given in the table, it may be of interest to know that during the high-rating test of 343.5 per cent, the heat in the fuel fired amounted to about 46,500 B.t.u. per hr. per cu. ft. of furnace volume.

The high efficiency of this equipment is of special note. At the time of installation the stokers selected were considerably longer than normal practice. Also the clinker-grinder pit was very much deeper than any that had been installed. It was believed that this would result in a very low combustible in the refuse, and it was hoped that the discharged ash would be at a relatively low temperature. A glance at the test results shows the low percentage of combustible in the refuse. The results of operation prove that quenching the refuse is seldom necessary. It has proved feasible to run the clinker grinders continuously, with very little adjustment. The speed of these grinders varies with the stoker speed since they are driven from the same shaft.

Vibration Phenomena of a Loaded Unbalanced Shaft while Passing Through Its Critical Speed

By A. L. KIMBALL, JR.,[1] and E. H. HULL,[1] SCHENECTADY, N. Y.

MANY problems in shaft whirling may be handled by a method analogous to that used in the solution of alternating-current-circuit problems, where transient oscillations are disregarded. It consists of solving directly for the condition of steady vibration by means of the diagram of forces and by making use of the magnitudes, directions, and phase angles of the forces involved.[2]

The particular problem of shaft whirling to be considered in this article is reduced to its simplest terms by assuming the rotor to be a disk-shaped flywheel, carried by a straight, weightless shaft with unbalance produced, for example, by drilling a hole in one side of the disk. The center of gravity G of the disk is then displaced a small distance e from the center line S of the shaft. Consequently when the shaft commences to rotate, G begins to describe a circle of radius e about S, which develops a centrifugal force whose magnitude would be $M\omega^2 e$ with a perfectly stiff shaft (M = mass of flywheel). However, since the shaft itself springs slightly, S is displaced outward from the center of rotation so that both S and G describe circles about the center of rotation O, the static position of S. The relations of these three points are shown in Fig. 1 and also in Fig. 2.

For the steady state of vibration at a given speed of rotation, a direct solution for amplitude of whirl of the shaft r_s and the phase angle ϕ can be obtained, expressed as a function of the speed of revolution. For purposes of analysis (see Fig. 2), let

$$\left.\begin{aligned} F_1 &= M\omega^2 r_g \\ F_2 &= cr_s \\ F_3 &= b\omega r_s \end{aligned}\right\} \quad \ldots\ldots [1]$$

where F_1 is the centrifugal force of the mass M as it whirls about O considered acting at its center of gravity G. F_2 is the elastic force exerted by the shaft tending to bring its center S back to its undeflected position O. F_3 is the equivalent of a frictional force resisting the whirling motion of the shaft, tangent to the path of whirl and vanishing when the deflection of the shaft r_s vanishes. For purposes of analysis it can be represented by F_3 applied at S since such a force develops a counter torque resisting the whirl of the shaft and flywheel as a whole about O and does not tend to resist the rotation of the shaft independently. F_3 will be assumed to have a value which depends upon the velocity of motion of S about O equal to $b\omega r_s$, where b is the damping constant.

For translational equilibrium, the force F_1 must exactly balance the resultant of F_2 and F_3 as indicated in the figure. For rotational equilibrium, the moment of F_3 about O must balance the driving couple.

From Fig. 2, by similar triangles,

$$\frac{e\sin\phi}{r_g} = \frac{F_3}{F_1} \quad \text{and} \quad \frac{e\cos\phi + r_s}{r_g} = \frac{F_2}{F_1}$$

from which

$$\sin\phi = \frac{F_3 r_g}{F_1 e} \quad \text{and} \quad \cos\phi = \frac{F_2 r_g}{F_1 e} - \frac{r_s}{e} \quad \ldots\ldots [2]$$

$$\tan\phi = \frac{\sin\phi}{\cos\phi} = \frac{\dfrac{F_3 r_g}{F_1 e}}{\dfrac{F_2 r_g}{F_1 e} - \dfrac{r_s}{e}} = \frac{F_3 r_g}{F_2 r_g - F_1 r_s} \quad \ldots\ldots [3]$$

Substituting from [1]

$$\tan\phi = \frac{b\omega}{c - M\omega^2} \quad \ldots\ldots [4]$$

From the value of $\tan\phi$

$$\sin\phi = \frac{b\omega}{\sqrt{(c - M\omega^2)^2 + b^2\omega^2}} \quad \ldots\ldots [5]$$

From [2]

$$\sin\phi = \frac{F_3 r_g}{F_1 e} = \frac{b r_s}{M\omega e} \quad \ldots\ldots [6]$$

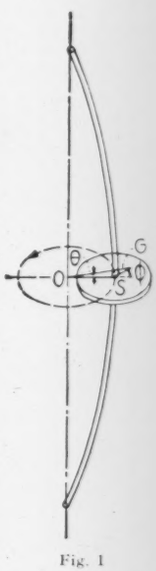


Fig. 1

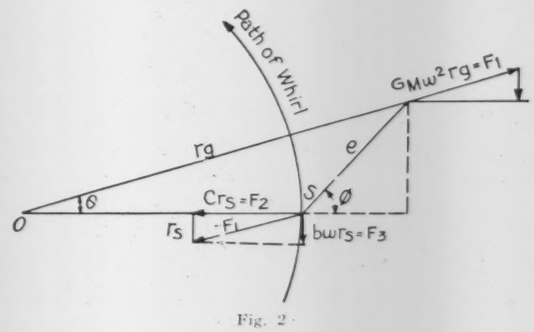


Fig. 2

FIG. 1 SHAFT WHIRLING DUE TO UNBALANCE, SHOWING RELATIVE POSITIONS OF CENTER OF MASS OF FLYWHEEL G, CENTER OF SHAFT S, AND CENTER LINE OF BEARINGS O, FOR CASE OF ROTATION BELOW CRITICAL SPEED

FIG. 2 EQUILIBRIUM DIAGRAM FOR CASE OF FIG. 1

Combining [5] and [6] and solving,

$$r_s = \frac{Me\omega^2}{\sqrt{(c - M\omega^2)^2 + b^2\omega^2}} \quad \ldots\ldots [7]$$

In the neighborhood of $\omega = \sqrt{\dfrac{c}{M}}$ both ϕ and r_s pass through rapid changes (see Fig. 8) and when

$$\omega = \omega_c = \sqrt{\frac{c}{M}} \quad \ldots\ldots [8]$$

ϕ = 90 deg. and r_s reaches almost its peak value r_{sc}

$$r_{sc} = \frac{Me\omega_c}{b} = \frac{e}{b}\sqrt{Mc} \quad \ldots\ldots [9]$$

This condition is known as the shaft critical speed, being exactly analogous to the critical voltage value at electrical resonance.

A remarkable change, however, takes place when the critical speed has been exceeded. An almost complete reversal of the positions of G and S occurs. This is shown in Figs. 3 and 4. The phase angle ϕ becomes greater than 90 deg. with the result that the center of mass G of the flywheel swings inward toward O and may take a position almost between O and the shaft center S. A consideration of the force diagram (Fig. 4) shows how the equilibrium is possible.

APPARATUS AND GENERAL METHOD

In order to check this theory quantitatively an actual rotating machine was so designed that such factors as mass, degree of unbalance, and degree of damping could be varied at will.

[1] Research Laboratory, General Electric Co. Respectively Assoc-Mem. and Jun. Mem. A.S.M.E.

[2] Since the writing of this paper, it has been called to the author's attention that an essentially similar method is discussed by A. Stodola in his Dampf- und Gas-Turbinen, p. 362.

Abstract of a paper presented at the Annual Meeting, New York, November 30 to December 4, 1925, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

To facilitate accurate observation, the model, drawings and photograph of which are shown in Figs. 5 to 7, was so designed that the critical speed was low and the amplitude of deflection was large, with the flywheel M carried on the end of an overhanging shaft instead of between the bearings. The steel shaft S, $^5/_{16}$ in. by 36 in., running in ball bearings at A and B and on the smooth step bearing C, carried at its top a disk-shaped flange F. A variable-speed motor drove this shaft through an intermediate shaft and the pulley P. The flywheel M was attached to the flange F by screws in slots by means of which the flywheel might be given varying degrees of eccentricity, and flywheels of several different weights were also provided. The eight paddles of the damper D, Fig. 5c, through the central hole of which the shaft revolved freely, dipped into the annular oil canal E, containing a mixture of manila gum and castor oil.

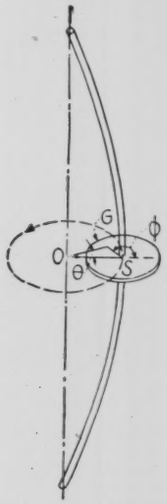


FIG. 3 SAME AS FIG. 1 BUT FOR ROTATION ABOVE CRITICAL SPEED, SHOWING CHANGE IN POSITION OF CENTER OF GRAVITY OF FLYWHEEL

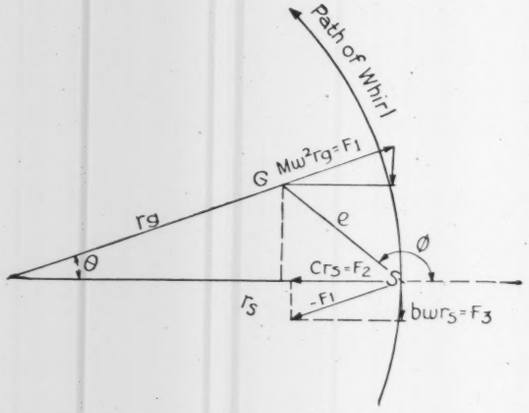


FIG. 4 EQUILIBRIUM DIAGRAM FOR CASE OF FIG. 3

The method of obtaining the required measurements is illustrated by the diagram of Fig. 6. The axis S of the shaft is marked by the vertical pointer which it carries, as shown in Fig. 5c. The point of zero shaft deflection O about which the shaft whirls is marked by a fixed downward-projecting pointer O (Fig. 5a). When a whirl builds up, as shown greatly exaggerated in the diagram of Fig. 6, the line joining the shaft center S and the center of gravity G of the flywheel M makes an angle ϕ with the line passing through the downward pointer O and the upward pointer S. In order to observe this angle during the whirling motion, the upper part of the apparatus was hooded to screen off outside light, and was instantaneously illuminated once every revolution by a neon glow lamp, shown in Fig. 5b and Fig. 7. The illumination was produced by an electric contact R, Fig. 5a, at the base of the shaft. Since this contact necessarily always took place at the same angular position of the shaft, the illumination was produced only when the line of eccentricity $e = SG$ was in a certain direction, irrespective of the direction of deflection of the shaft $r_s = OS$. For instance, in Fig. 6, when the speed of revolution is raised nearer to the critical speed, SG moves over to $S'G'$, but still points in the same direction.

The direction of shaft deflection OS is located readily with the eye by finding where the pointers O and S line up at the instant of illumination. This is accomplished by means of a device similar to the mariners' pelorus, consisting of the two upright sighting vanes W, Fig. 5, attached to the base G, capable of rotating about the center line of the bearings on which the indicator U is mounted, by means of which the angle can be read from a scale attached to the frame of the machine. When the variations of the angle ϕ are thus determined, the amount of the deflection OS, or the amplitude of the whirl, is measured by the pair of micrometers T shown diagrammatically in Fig. 5a as regards their position and also photographically in Fig. 7.

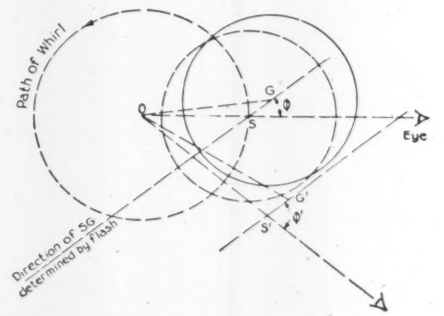


FIG. 6 DIAGRAMMATIC REPRESENTATION OF METHOD OF MEASURING PHASE ANGLE

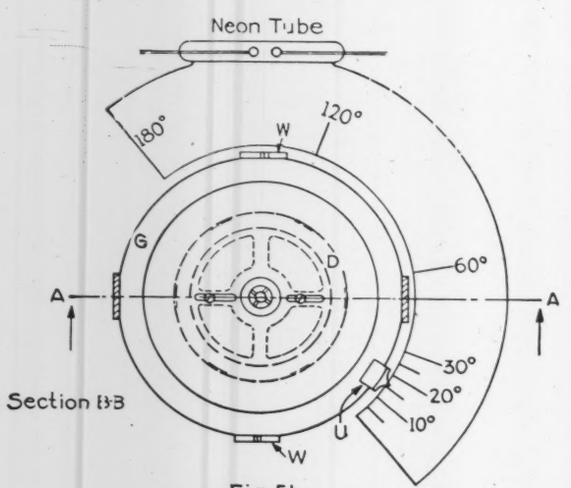
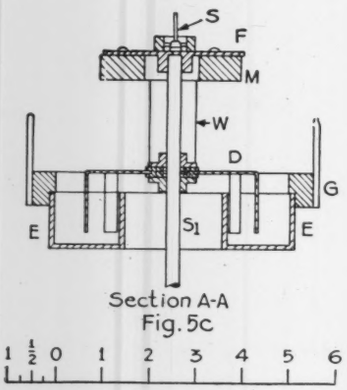


Fig. 5b



Section A-A
Fig. 5c

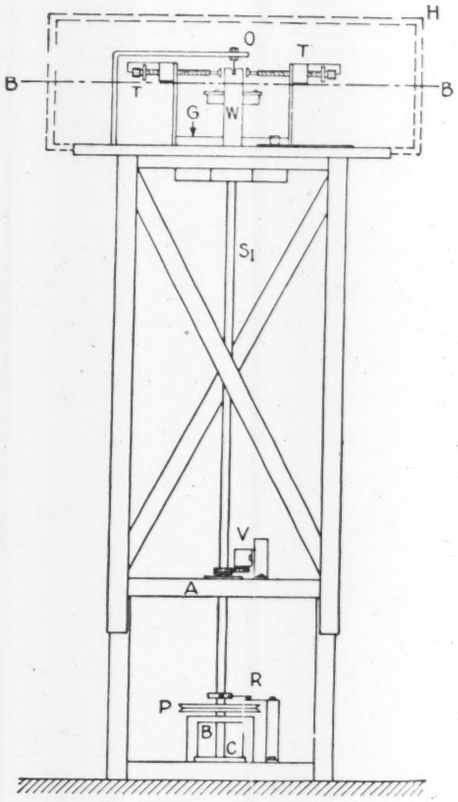
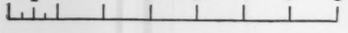


Fig. 5a



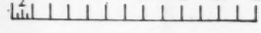


FIG. 5 DETAILED DRAWING OF APPARATUS

EXPERIMENTAL PROCEDURE

As it was impossible to obtain a perfectly straight shaft of the dimensions required, two centering devices were necessary—one at the damping-paddle bearing and another holding the vertical pin on the end of the shaft. The damping fluid used, a mixture of manila gum and castor oil, was chosen because its variation of viscosity with temperature was small, and also because its stiffness could be changed at will by varying the proportions of the mixture.

The neon glow lamp was supplied with current from a plate circuit of two 50-watt pliotrons in parallel which were operated by the contact points R placed at the base of the model shaft and controlling the grid potential. Once each revolution the grids, normally at a negative potential, were made positive, thus allowing an instantaneous current to flow in the plate circuit. This arrangement was used to avoid sparking at the contact points and the consequent irregular flashing of the lamp.

The intermediate jackshaft through which the machine was driven was provided with a flywheel and with the machine driven from a storage battery, stable operation was obtained at all speeds, however near the critical.

COMPUTATION OF CURVES AND DISCUSSION

The critical speed of the shaft for each attached flywheel was obtained both by observation of the maximum amplitude and by calculation following the method of Morley,[3] which takes account of the weight of the shaft as well as that of the flywheel, giving an equivalent value of M.

Knowing the critical speed of the model for the conditions of the run and knowing that the phase angle is 90 deg. at this speed, the

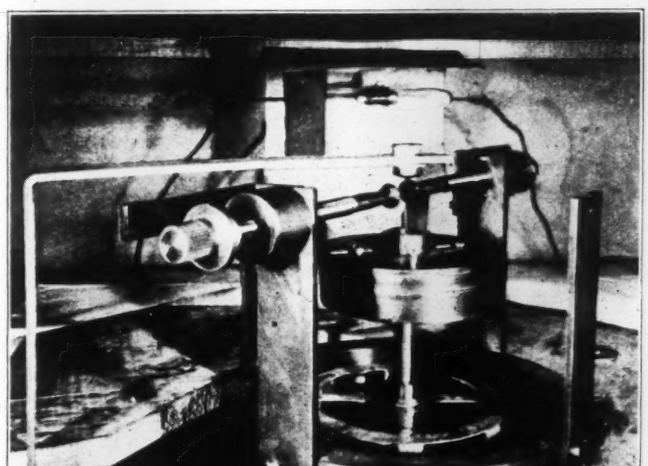


FIG. 7 DETAIL OF TOP OF APPARATUS

actual 0- and 180-deg. lines for the phase angle can be located on the experimental phase-angle curve already drawn.

Using an approximate value for the eccentricity, determined by direct measurement from the apparatus, and using the amplitude r_{sc} at critical speed, an approximate damping constant is obtained from Equation [9], M being the equivalent mass. Upon substituting in Equation [7] the value of ω and the corresponding value of r_3 obtained from the high-speed reading, and the value of b just obtained, and solving for e, a more nearly correct value of the eccentricity can be obtained. An exact value of b can be obtained now by putting this new value of e in Equation [9] and again solving. The elastic constant of the shaft is obtained from Equation [8], $\omega_c = \sqrt{\frac{c}{M}}$, where ω_c corresponds to the critical speed of rotation of the shaft. Direct measurement verified the value of the elastic constant obtained by this equation.

Thus all the constants needed to determine the shape of the curves of phase angle and of amplitude plotted against speed were obtained from observations at easily determined points, namely, at critical speed and at a very high speed.

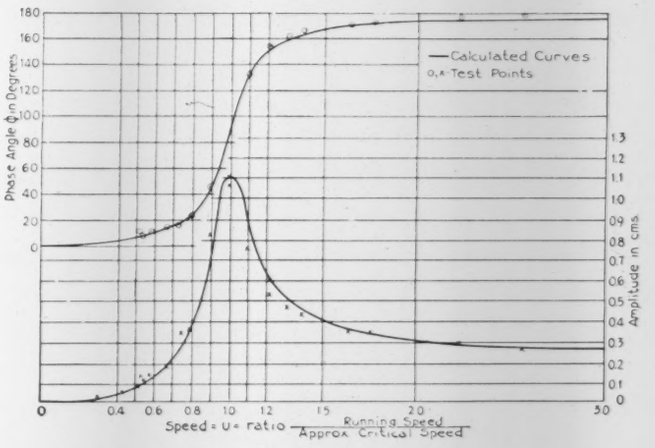

Calculated Curves
Test Points
Phase Angle ϕ in Degrees
Amplitude in cms.
Speed = u = ratio Running Speed / Approx. Critical Speed

FIG. 8 PHASE-ANGLE AND AMPLITUDE VARIATION WITH SPEED IN A WHIRLING SHAFT FOR A SMALL AMOUNT OF DAMPING, SHOWING AGREEMENT BETWEEN EXPERIMENTAL AND CALCULATED RESULTS

Equivalent mass, M = 0.683 gram		Eccentricity, e = 0.2268 cm.	
Elastic constant, c = 341 grams per cm.		Damping factor, b = 3.168 grams per cm. per sec.	
Critical speed, ω_c = 3.56 r.p.s.		Curve factor, a = 0.208	

In plotting the curves, by substituting u and a and making use of Equation [6], Equations [4] and [7] were changed to the forms

$$\tan \phi = \frac{ua}{1 - \omega^2} \quad \ldots\ldots [10]$$

$$r_s = r_{sc} \sin \phi = \frac{eu}{a} \sin \phi \quad \ldots\ldots [11]$$

where

$$u = \frac{\text{running speed}}{\text{critical speed}} = \frac{\omega}{\omega_c} = \omega \sqrt{\frac{M}{c}} \quad \ldots\ldots [12]$$

and

$$a = \frac{\text{eccentricity}}{\text{amplitude of whirl at critical speed}} = \frac{e}{r_{sc}} = \frac{b}{\sqrt{Mc}} \quad [13]$$

(See Equation [9])

From these equations, ϕ and r_s were plotted against u (proportional to ω) as shown in Fig. 8.[4] Thus the curves represent the variations of ϕ and r_s required by theory, using constants determined by careful measurement. The circles and crosses, which indicate the values for ϕ and r_s actually observed as the speed was varied, are seen to fall nearly upon the theoretical curves.

The agreement between these curves and the test points is very good for the amplitude curve: below critical speed the mean variation is 4 per cent; above critical it is 2 per cent of the critical-speed value. The average deviation of less than 2 deg. of the phase-angle points from the theoretical curves is well within the limit of accuracy of the apparatus. In nearly every case it will be seen that the test points are evenly distributed on either side of the calculated curves.

[3] Arthur Morley, *Engineering*, July 30, 1909, p. 135.

[4] This curve was obtained with a small amount of damping. Curves for medium, heavy, and very heavy damping are also given in the original paper.

Discussion

PAUL A. HEYMANS[5] in his discussion said that the question which had arisen in his mind was whether the authors' theory could be extended to the action of internal-frictional forces which were the more fundamental forces to be considered in whirling.

The theory could be extended to internal-frictional forces in its present form because Equations [1] did not express the instantaneous elastic equilibrium at any point of the rotating shaft. Indeed, F_3 should then represent the instantaneous value of the internal-frictional force. Writing $F_3 = b\omega r_s$, it would be assumed that the plane of the deflected shaft rotated with the angular velocity ω of the shaft itself around its deflected axis. If this assumption were correct, there would be no forces due to internal friction. Considering the deflected shaft as represented in Fig. 1 of the paper, if the plane of the deflected shaft were rotating with the same angular velocity as the shaft itself around its deflected axis, each line of fibers parallel to the deflected axis of the shaft would remain in the same state of stress. Whereas if the plane of the deflected shaft were not rotating with the same angular velocity as the shaft, only then would each line of fibers alternately be stretched and contracted, and the internal-frictional forces due to this alternating strain would be those which tended to drag the plane of the deflected shaft with the rotating shaft. It followed that the velocity ω in the relation $F_3 = b\omega r_s$ should be different from the frequency ω of rotation of the shaft around its deflected axis in the relation $F_1 = b\omega^2 r_s$.

Professor Heymans said he would be interested to know if the authors with their present apparatus could not have measured this velocity of rotation of the plane of the deflected shaft and thereby secured direct information on internal friction itself.

When extending the theory to internal friction the value of the coefficient of friction b could not be assumed to be constant. Considering a linear free damped oscillator of mass m, the dynamic equation of motion was:

$$m\frac{d^2x}{dt^2} + b\frac{dx}{dt} + a^2x = 0$$

where a^2x was the elastic force, $b\dfrac{dx}{dt}$ was the frictional force, and $m\dfrac{d^2x}{dt}$ was the inertia force. The solution of this equation was

$$x = Ax_1 + Bx_2$$

where

$$x_1 = e^{-\frac{b}{2m}t} \cdot e^{+\sqrt{\frac{b^2}{4m^2} + \frac{a^2}{m}}\,t}$$

$$x_2 = e^{-\frac{b}{2m}t} \cdot e^{-\sqrt{\frac{b^2}{4m^2} + \frac{a^2}{m}}\,t}$$

and where A and B were two integration constants. The amplitude of the free vibration was an exponentially decreasing value $e^{-\frac{b}{2m}t}$, which would become zero only after an infinite time. In any physical case, the oscillation died out within a finite time which might be very short if b was somewhat great. This discrepancy between theory and observation was due to the fact that the frictional constant was not a constant but depended upon the velocity, increasing rapidly once the velocity had fallen below a value v_1 as shown in Fig. 9. The coefficient of friction b was only constant for values greater than v_1.

As each fiber of the shaft was alternately stretched and contracted with a frequency depending upon the number of revolutions per second of the plane of the deflected shaft and the number of revolutions of the shaft around its deflected axis, its velocity of deformation varied, passing cyclically through zero at the time of maximum tensional and compressional displacements and through a maximum when the deformation went through its zero value. When writing $F_3 = b\omega r_3$ it was assumed that the frictional coefficient b was constant throughout each cycle and for all velocities ω.

In Equations [1], $F_2 = cr_s$, which related the elastic restoring force to the transverse deflection, could not the factor of proportionality have been given an explicit expression? Indeed, the transverse deflection r_s of a shaft which was supported at its end was

$$r_s = \frac{1}{48}\frac{F_2 l}{EI}$$

where l = distance between the supports
E = Young's modulus of elasticity
I = moment of inertia
F_2 = deflecting force which was equal and opposite to the elastic restoring force.

In the case of the apparatus of Fig. 5*a* in the authors' paper a similar relation for the deflection when the shaft extended beyond one of the supports should have given the value of the coefficient c. If this were the case, how did the value calculated that way compare with the values observed?

S. Timoshenko[6] wrote that in the authors' work a stroboscopic method had been used for obtaining the instantaneous position of the disk and the shaft. He believed that continuation of that work might give interesting data and might assist in clearing up points which, until now, had had no satisfactory analytical explanation. It would be interesting, for instance, to obtain by using the stroboscopic method a complete picture of the vibratory phenomena of a horizontal shaft produced by its own weight (critical speed of secondary type). The study of the transient oscillations when the speed of the shaft was going through the critical range might also yield interesting results. It would be important, for instance, to get experimentally the maximum amplitude when different rates of changing the speed of the shaft and different intensities of damping were used while passing through the critical speed.

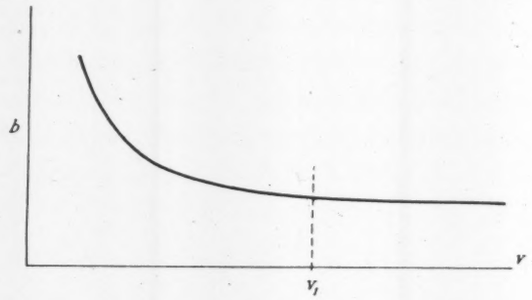


FIG. 9

H. D. Taylor[7] contributed a discussion in which he wrote that the usual definition of critical speed had been that speed at which a shaft became unstable, its stiffness being completely neutralized by centrifugal forces, so that it became incapable of resisting the slightest deflecting tendency. While this was a theoretical definition, based on a simple analysis which neglected friction, it was fairly well borne out by experience with machines and models which were none too well balanced. The practical result had been that it had become a fixed rule of design to avoid critical speeds, as calculated, by wide margins. That was undoubtedly a wise policy, but not one conducive to familiarity with the actual behavior of shafts at critical speed.

Experience with models and with commercial machines had convinced Mr. Taylor that the vibration encountered at critical speed in general was not evidence of instability so much as of unbalance. For instance, refined balancing of a model rotor, which had been extremely violent even in passing rapidly through critical speed, resulted in such smooth operation that the critical speed could not be detected, however slowly it was passing through. In fact, the speed could be held constant at the exact critical value, as nearly as could be readily measured, without the least tendency for vibration to build up. Furthermore, the addition of measured weights in successive runs, to cause intentional unbalance, produced definite deflections at critical speed, which proved to be approximately proportional to the degree of added unbalance.

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[6] Research Engineer, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa. Mem. A.S.M.E.

[7] General Electric Co., Schenectady, N. Y.

Following these experiments, the equations of Jeffcott had been called to the attention of Mr. Taylor by Dr. B. L. Newkirk, with the suggestion that they be compared with the performance of the model. This suggestion was carried out in a special series of tests, using dial indicators to measure the amplitude of shaft vibration, and an improvised stroboscopic device to indicate the "phase angle," or angle of lag, between the heavy side of the rotor and the deflection of the shaft. Some of the results might be outlined as follows:

1 With the same degree of unbalance, the amplitude reached at critical speed decreased as the quantity of oil supplied to the bearings was increased; this indicated the oil film in the bearings as the major source of damping.

2 With constant oil conditions, the "critical amplitude" was definite, repeatable, and proportional to the degree of unbalance. Acceleration in moderate degree had no appreciable effect.

3 The test curves of amplitude and angle of lag vs. speed, when compared with other curves representing the theory, showed good general agreement as to shape, though some minor differences were apparent.

4 No direct measure of the damping forces considered in the theory being available, a number of assumptions as to the law governing the variation of damping with speed, amplitude, etc., were introduced into the theory, and the resulting equations were found to check with the tests about as well as those based on the usual assumption (damping proportional to velocity), but no better.

The conclusion drawn was that when all the conditions assumed in the theory were fulfilled, at least approximately, actual shaft behavior agreed quite closely with the theoretical.

E. O. Waters[8] in his discussion of the paper said that the authors' apparatus did the same thing as a balancing machine in which a loaded shaft was rotated first forward, then backward, and the "high spot" marked each time with a scriber. If it were not for the damping force there would be only one high spot, and the heavy side of the shaft would be immediately located.

The authors had assumed that the friction was of a viscous nature, i.e., was directly proportional to the velocity. It was, however, a simple matter to get the same general results with any kind of friction, either constant or a function of the velocity. For example, if $F_3 = bw^n r_s^n$, then the phase angle ϕ, at critical speed, was 90 deg., and the amplitude

$$r_s = \frac{1}{\omega_c} \sqrt[n]{\frac{Me\omega_c^2}{b}}$$

This latter expression indicated that an increased intensity of damping, either in the index n or the factor b, would correspondingly reduce the vibration, and if either one became zero, the amplitude increased indefinitely.

Were there other forces besides friction that could prevent excessive vibration at the critical speed? There seemed to be a general impression that a shaft could "safely pass through" this speed if it were not allowed to dally on the way. Jeffcott, in the paper to which the authors referred, showed that a finite time interval was required for building up a large amplitude at the critical speed even when the friction was zero, and suggested that this made it possible to get through the speed without undue danger to the shaft. More recently, Messrs. Thearle and Dent had endeavored to prove that an angular acceleration impressed on the shaft would have the same general effect as a damping force, i.e., a phase displacement was produced, and the amplitude of vibration was restricted. The results obtained were surprisingly simple, but these authors had neglected the radial acceleration of the shaft in comparison with the tangential, although it was known that, as a shaft just came up to a critical speed (damping being zero) the radius of its path was very suddenly increasing, while the velocity of rotation was almost unchanged.

The equations of motion for an unbalanced shaft rotating with *variable* angular velocity were easy enough to set up, but not so easy to solve. Professor Waters wished to learn whether any rigorous solution had been obtained; also, whether any other action besides that of friction had been found that was capable of restraining the vibration at critical speed. If not, it should be possible to take almost any small shaft, mount it in self-aligning bearings, place it in a vacuum, and speed it up until it breaks.

Burt L. Newkirk[9] wrote that the proportions of the authors' apparatus were such that, in comparison with rotors of motors, generators, and turbines, its rotor was slender, the unbalance was great, and the damping was great. These features were purposely exaggerated to make the apparatus suitable for convenient comparison with the commonly accepted theory of shaft behavior. The interesting result of this study was the close agreement between the calculated curves and the results of observation.

But in interpreting tests of model rotors it was important to remember that rotors of heavy machinery differed in certain fundamentals from models. It was difficult to balance a model rotor relatively as well as a turbine or generator rotor was balanced. Models, especially those intended for quantitive study, were likely to have ball bearings, whereas heavy rotors run in journal bearings had, in many cases, a length equal to twice the diameter. The bearing supports of model rotors were usually rigid enough to satisfy the assumption of the theory that the supports were entirely rigid. The bearing standards of heavy rotors could hardly be made rigid enough to fulfill this condition. The heavier the rotor, the more likely was it to be found that the yield of the support at the bearings when the load was applied was comparable with the deflection of the shaft at its middle. Not only this, but the rigidity of the bearing support was different in different directions.

These were three fundamental differences, and the resulting divergence in shaft behavior was correspondingly great. Because of these circumstances heavy rotors, when well balanced, showed only very slight vibration, or none at all, when running at their calculated critical speeds.

With rotors of moderate size, say, of 5000-kw. turbo-generators of flexible-shaft design, some vibration was found near the calculated critical speeds, but resonant vibrations of one sort or another developed at other speeds. These resonant vibrations were usually determined by the elastic characteristics of the bearings or other parts of the structure.

In the case of the largest rotors, bearing elasticity had a predominant effect in determining the critical speed, so that critical-speed phenomena did not occur at all as contemplated in the common critical-speed theory. Here vibration was found in a horizontal plane at one speed and in a vertical plane at a different speed, and possibly other vibrations arising in different parts of the structure at still different speeds. The stimulus to these vibrations was usually the unbalance.

On account of these differences, a point of view somewhat different from that of the common theory of shaft behavior had proved very valuable to Mr. Newkirk. It was suggested by Dr. Moss, of the Thomson Research Laboratory. A rod was chucked in a lathe with no support at the projecting end of the rod, but passed through a guard ring so that the rod would not whip out too far when the lathe ran. If the lathe were run causing the rod to rotate and setting it into transverse vibration, it would be found that the rod would vibrate in a plane, or about as it would if the lathe were not running. That was, rotation and vibration, might be superposed upon a shaft without mutual interference. This behavior was of course in conformity with the mechanics of elastic materials, but the point of view was usually not emphasized in the theory of shaft behavior. From this point of view the critical-speed phenomena of shafts were simply resonant-vibration phenomena, and by treating them as such it was possible to take into consideration the effect of unbalance, length of bearings, elasticity of bearings, and other circumstances not enumerated above. It would be difficult if not impossible to evaluate the effect of these circumstances on the vibrational behavior of machines, on the basis of the common theory of shaft behavior.

Considered from the point of view outlined above, the calculated critical speed of a machine was the speed at which resonant vibration would develop if the balance were bad, the bearings short and infinitely rigid, and if the machine were run at this speed long enough for resonance to build up. As a matter of fact, however, well-balanced machines did run at their calculated critical speeds and at all other speeds within limits set by stresses due to centrifugal force without excessive vibration.

[8] Asst. Professor of Mechanical Engineering, Yale University, New Haven, Conn. Junior A.S.M.E.

[9] Research Laboratory, General Electric Co., Schenectady, N. Y.

The Heat-Balance Method of Testing Centrifugal Compressors

By M. G. ROBINSON,[1] LYNN, MASS.

Centrifugal compressors are often driven by steam turbines with and without intervening gear trains. To determine the shaft power transmitted to the compressor by its driver from efficiency tests on the turbine and estimates of the gear losses, involves considerable labor, time, and expense. The heat-balance method herein described is simpler, and more direct. In this method the principle is used that a balance exists between the mechanical energy supplied by the rotation of the shaft and the heat-energy increase in the air which is being compressed, the heat-energy increase in the cooling water used, and the heat lost from the casing, bearings, and packings. With proper testing apparatus and due precautions, this heat energy may be accurately measured, and hence the power input established. Very satisfactory results have been secured by the application of this method. There are given details of the fundamental theory, some representative test data, and a complete description of the apparatus used.

THE builder of centrifugal compressors, because of the high rotational speed involved, employs steam turbines, and at times gear trains, to drive his apparatus. When the efficiency of the driver under test conditions is known, the input to the compressor (which is represented, of course, by the output of the driver) can be computed, and hence the efficiency of the compressor established. However, the labor involved in making a test on the gear losses, or a steam-rate power-output test on the turbine, is very appreciable, and often prohibitive. Sometimes it is even impossible to reproduce on test the rated conditions of the driver, as is often the case with very high steam pressures or superheats; or, again, in connection with compressors designed to handle gas of low specific gravity. In the latter case, the machine when tested with air requires power in great excess over the rated, and hence the driver is of necessity operated under abnormal conditions. This makes the calculated output of the driver subject to serious error.

The advantage of having some direct way, independent of the driver, of determining the power input to the compressor is therefore quite evident. This can be done by measuring the equivalent heat energy appearing during the process of compression. Within the last three years a great deal of testing has been done at the Lynn Works of the General Electric Co., by such a method, which may be called the "heat-balance method," with results fully trustworthy, it having been again and again checked by independent means.

Theory

The theory underlying the method is simple. It is based on the first law of thermodynamics that "heat and mechanical energy are indestructible and interconvertible." If one is skilful enough to determine all the heat energy appearing during a mechanical action, this energy will "balance" the energy supplied by the mechanical action. Let us examine what happens during the operating cycle of a centrifugal compressor, and see how the principle stated could be applied. The driver, be it a turbine or a motor, delivers a certain amount of mechanical energy to the compressor rotor. This energy is used up as follows:

a A part goes to increase the energy content of the air which is being compressed and delivered into the discharge pipes. It manifests itself in a temperature and pressure rise and delivery of the air.

b A part is absorbed by the cooling water in the water jacket surrounding the air passages, and manifests itself in a temperature rise of the water.

c Some is dissipated into the surrounding atmosphere from the surface of the casing by conduction, radiation, and convection.

d Some is lost in bearing friction, the heat developed being carried off by the oil, or else dissipated into the surrounding atmosphere.

e Some is carried off into the surrounding atmosphere by the air escaping through the clearance between the shaft and the packing on the high-pressure end of the machine.

The problem which confronts one is then the evaluation of each of the items enumerated above. Usually, items *a* and *b* are of major importance. Item *a*, the energy absorbed by the air, depends upon the specific heat, the flow, and the temperature rise of the air. It can therefore be evaluated with a high degree of precision. In case of compressors with no water cooling this energy represents practically the entire shaft input. In water-cooled compressors this energy may be only 50 per cent of the total in case of low-pressure machines, and even as low as 20 per cent in case of high-pressure multi-stage machines (see Table 1).

Item *b*, the energy carried off by the cooling water, depends on the weight of water used and on its temperature rise. It also can be determined accurately. In case of high-pressure multi-stage compressors this item is the most important one (see Table 5).

Items *c*, *d*, and *e* in the average case amount to $\frac{1}{2}$ to 2 per cent each, near and above full load, and hence their magnitude does not have to be established with any great degree of precision, a 10 per cent error in estimating any of these items having an effect of less than $\frac{1}{4}$ per cent on the overall input. However, at partial loads the relative importance of items *c*, *d*, and *e* becomes more marked. It follows that the results obtained by this method are apt to be in error at partial loads, since the nature of items *c*, *d*, and *e* is such that it is difficult to establish them very accurately.

The test data given in Table 1 illustrate the actual energy distribution in a few representative cases, and so indicate the degree of refinement required in the determination of each item. These tests were carried out with such care that the summation of the items enumerated (*a* to *e*) actually shows the balance between the heat energy measured, and the known input to the driver. The usual agreement is within 2 per cent or better.

Theoretical Formulas and Basic Factors

The detailed formulas and other information required in the computation work are given fully in Appendix No. 1 of the unabridged paper. For convenience in reference in the general discussion which follows, the five fundamental expressions for the energy subdivisions, *a* to *e*, described in the article are also listed below:

Air hp. $= Jc_p(T_d - T_i)w/550$ [a]

Water hp. $= J(t_d - t_i)W/550$ [b]

Radiation hp. $= JS(K/3600)(t_s - t_a)/550$ [c]

Bearing hp. = known by test, or estimated from appropriate formula [d]

Packing hp. $= Jc_p(t_p - t_i)w_p/550$ [e]

where:

J = mechanical equivalent of heat

c_p = specific heat of air at constant pressure

$T_d - T_i$ = temperature rise of the air

w = weight of air compressed

$t_d - t_i$ = temperature rise of the cooling water

W = weight of cooling water

S = exposed surface of compressor casing

K = coefficient of heat emissivity from casing

$t_s - t_a$ = temperature difference between surface casing and surroundings

$t_p - t_i$ = temperature difference between air leaking by packings and inlet air

w_p = weight of air lost through packing leakage.

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[1] General Electric Co., River Works. Assoc-Mem. A.S.M.E.

Presented at the Annual Meeting, New York, November 30 to December 4, 1925, of The American Society of Mechanical Engineers. Abridged.

The total power input is, of course, given by the sum, $a + b + c + d + e$. The similarity and the simplicity of the formulas, for both the air hp. and packing hp. is due to the well-known fact that, since air may be considered a perfect gas, any energy increase in it is manifested by a temperature rise only. In the actual calculations care must be exercised in selecting the proper value for c_p, taking due account of its variation with temperature, pressure, and humidity, in the light of the most recent experiments as shown in the unabridged paper. Failure to do so may, in an extreme case, cause an error of as much as 4 per cent.

So much vagueness had usually surrounded item c, the energy lost by the casing through radiation, conduction, and convection, that a special study was made of the subject. As is evident from formula [c], three factors affect this item: (1) the surface exposed (S); (2) the temperature difference between the surface and the surrounding atmosphere ($t_s - t_a$); and (3) the coefficient of emissivity (K).

During a test, the surface is conveniently subdivided into portions of approximately equal temperature, and that temperature observed. The surrounding temperature is measured in a sufficient number of places to insure a representative value. The total power is the summation of losses from the several areas. A proper value of the coefficient of emissivity may be selected from curve in Fig. 1 which is based on tests made by L. B. McMillan.[2] This coefficient gives the combined effect of heat loss by conduction through the surface, radiation from the surface, and convection. Of these, the last named is of major importance. Although there appears to exist an appreciable variation in the coefficient with the temperature difference, it should be noted that as applying to compressor tests, values of 2.0 to 3.0 will practically cover the range. The validity of the coefficient under actual test conditions was checked by the writer, using what may be called "the air-flow method" described fully in the unabridged paper.

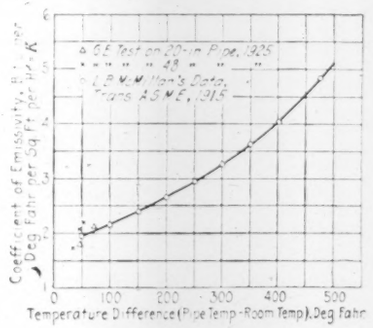
Coefficient of Emissivity, B.t.u. per Deg. Fahr. per Sq. Ft. per Hr. = K
G.E. Test on 20-in. Pipe, 1925
" " " 48 " " "
L. B. McMillan's Data, Trans. A.S.M.E., 1915
0
100
200
300
400
500
Temperature Difference (Pipe Temp. - Room Temp.), Deg. Fahr.

FIG. 1 EMISSIVITY TEST ON BARE PIPE

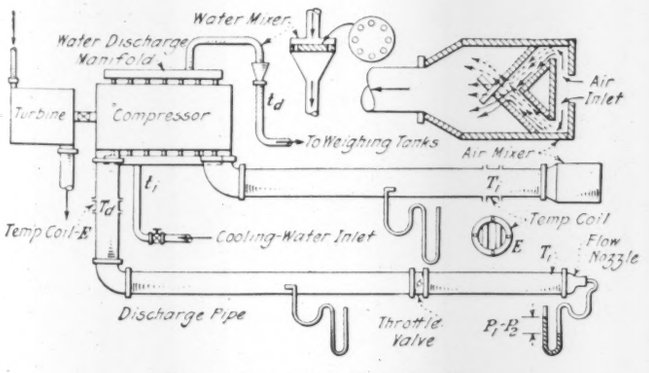

FIG. 2 DIAGRAM OF TEST SET-UP

DESCRIPTION OF APPARATUS AND PROCEDURE

The degree of accuracy which can be obtained from a heat-balance test depends wholly on proper apparatus and the exercise of sufficient care in conducting the test. The general arrangement of the set-up used is shown on the diagrammatic sketch, Fig. 2. It will be most convenient to discuss the various features in order in which they affect the five subdivisions of the total energy input.

a Power Absorbed by the Air. This depends on the specific heat (c_p), the temperature rise of the air, and the flow. The variation of c_p with the moisture contents is known. During the tests the relative humidity is determined from readings of wet- and dry-bulb thermometers, the sling-type instrument being preferred. The flow is usually measured by the nozzle method, as described in detail by S. A. Moss.[3]

The determination of true temperature of both the inlet and discharge air is probably the most difficult task in the method. When testing is done in a factory building where steam may be discharging in one corner, and cold outside air flowing some hundred feet farther, appreciable temperature variations are apt to exist, and convection currents are set up. A thermometer placed indiscriminately somewhere near the machine may differ several degrees from the true temperature of the air actually passing through the intake of the compressor. A thermometer inserted somewhere in the discharge from the compressor may be subject to the action of a stray air jet, and will not necessarily indicate the true average temperature of the discharge air.

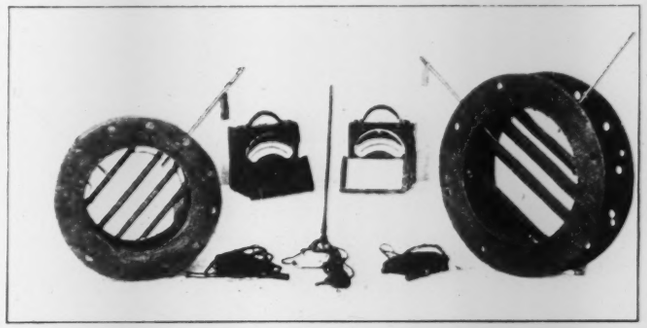

FIG. 3 EQUIPMENT USED FOR MEASURING TEMPERATURES BY THE RESISTANCE METHOD

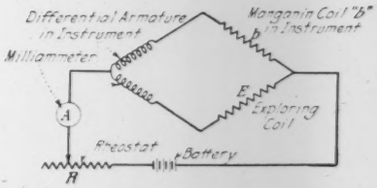

FIG. 4 DIAGRAM OF RESISTANCE-THERMOMETER CIRCUIT

To obviate these difficulties, there has been developed a system of resistance thermometers which are shown on Fig. 3. The basic principle is that of determining the temperature from a change in the resistance of a known element. The resistance elements are usually inserted in a pipe section (of same diameter as the main piping) about 10 inches long and provided with flanges on each end. They are placed directly in the inlet and discharge pipes leading to and from the compressor. In this way all the air is made to pass over the resistance elements, and a good representative average temperature is secured. The resistance wires are of copper, and are wound on four bakelite struts of streamline section and connected in series. There are provided tapped holes which enable mercury thermometers to be used in conjunction with the coils, and thus afford an immediate check on tightness of electric connections, grounds, etc.

The electrical circuit can be traced from Fig. 4. The indicating instrument is of the constant-current type. In the operation, the current in the circuit is held constant by means of the rheostat (R) at the design value of the instrument. The various resistances of the instrument are adjusted so that at 25 deg. cent. (77 deg. fahr.) the current arriving at the juncture of the differential armature through the manganin coil is equal to that arriving at the same junction through the exploring coil (E); this determines the normal point (zero deflection) of the instrument. When the exploring coil (E) is at a higher temperature than 77 deg. fahr. its resistance is increased; the two sides of the circuit through the differential armature are unbalanced, consequently more current flows through coil (b) than through coil (E) and the pointer of the instrument moves up scale. In the case that the temperature of coil (E) is lower, coil (b) takes less current than coil (E) and the pointer moves down scale.

As an additional precaution there has been used at times an "air mixer" which can be seen in the diagram of Fig. 2. In this arrangement the entire air quantity is taken through a horizontal

[2] The Heat Insulating Properties of Commercial Steam Pipe Coverings. Trans. A.S.M.E., 1915, vol. 37.

[3] The Impact Tube, Trans. A.S.M.E., 1916.

opening of a fairly large wooden box so as to reduce the initial temperature variations. The air jets are then divided and quite thoroughly mixed, as shown in the diagram. By using this air mixer, very uniform temperatures across the section of the inlet are obtained.

b Energy Absorbed by the Cooling Water. This energy may be as much as 50 per cent or even more of the total energy supplied, and hence all precautions possible must be exercised in its determination. It depends on the product of the temperature rise and the weight of the cooling water which is being circulated. Usually there is practically no variation in the temperature of the water as it flows through the inlet pipe. Hence in determining its temperature all that is necessary is the use of a sufficient number of properly calibrated thermometers with sufficiently fine graduation. The problem is more troublesome on the discharge end, where an individual determination may not be truly representative. This uncertainty was overcome by using a "water mixer," which may be seen installed in the vertical section of the pipe in Fig. 2. The action of the mixer will be evident from the insert in Fig. 2. By having the main stream impinge upon the central solid portion of the plate, the velocity of any individual jet if present is destroyed and a certain amount of mixing takes place. The water is then forced out through a number of small holes drilled near the outer periphery. The many jets discharging through these holes into the gradually converging cone are thoroughly mixed, and when the stream issues from the cone the water has a uniform temperature throughout the section. A single thermometer properly graduated and calibrated gives a reliable and truly representative indication of the average temperature.

During the entire test the flow of the cooling water is kept constant by means of suitable hand-controlled throttle valves. The actual amount is determined usually by direct weighing in tanks specially set up for the purpose.

c Energy Dissipated into the Surroundings from the Casing Surface. During the progress of the test, careful measurements are made of the temperature of the various parts of the casing. The temperature of the surroundings is also observed. Each test point is held a sufficiently long time to insure constant thermal conditions having been attained. The coefficient of heat loss, K, is taken from the curve in Fig. 1, or at times determined by actual test on a pipe section simultaneously with the performance test proper, using the air-flow method previously referred to. It should be noted that the energy loss from this source in case of water-cooled machines is small. In case of machines without water cooling, it may be of importance (see Table 1).

d Bearing Hp. Whenever possible, the bearing loss is determined by test. During the performance test, care is taken to have oil of same viscosity as that used during the bearing tests. When a calorific test is made, the oil and water should be weighed or metered through an orifice, and due precautions taken to run the test long enough to insure constant conditions.

e Packing Hp. The clearances between the packings and the shaft are carefully measured both during the process of assembly and after the test. Throughout the test, observations are made as to the condition of the packings, so that any imperfection resulting in an unduly large leakage is quickly noticed.

Representative Tests Results

Several attempts were made during the progress of the work to check the heat-balance method by direct comparison of the power calculated from the measured input to a driver of known efficiency with the power obtained by the heat-balance method. Motor-driven as well as turbine-driven sets, with and without an intervening gear train, were tried. The results reported here (see Table 1) represent tests corresponding to conditions at which the output of the driver could be ascertained with a good degree of approximation (1 to 2 per cent). The losses of induction motors were determined from tests in accordance with the specifications of the A.I.E.E. standards of 1922. The outputs of the turbines were calculated from data on water-brake and generator tests of similar units.

Case 1 refers to a 75-hp. motor-driven set. It was a single-stage fabricated steel compressor, without water jacket and with the impeller wheel overhung from the motor shaft. It will be noted that the results show an agreement between the power input to the compressor as computed from the heat-balance method and that obtained from the measured input and the known motor losses within $2^1/_2$ per cent or better. The bearing losses are not included, being charged to the motor. The packing loss was negligible. The major item is, of course, the air hp., as in any unit without water cooling.

Case 2 refers to a 175-hp. motor-driven set, the compressor being coupled to the motor through the medium of a gear train (see Fig. 5). The efficiency of the motor was known to a fair approximation ($^1/_2$ to 1 per cent). The losses of the gear train were determined by a separate test, the gear being uncoupled from the main motor and driven idle by means of a small calibrated motor. The tabulation shows extremely satisfactory agreement between the results of the two methods, the differences varying from 0 to 2 per cent. Again the major item is the air hp.

Case 3 refers to a test made on a model compressor with a wooden casing of appreciable thickness, so that the radiation loss was practically negligible. The compressor was driven by a 75-hp. 3500-

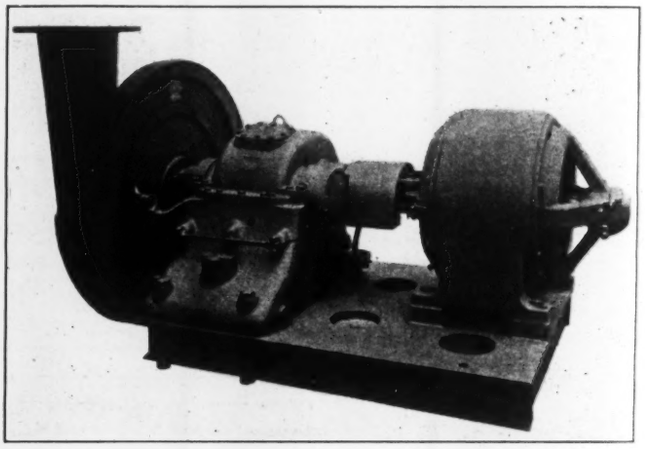

Fig. 5 Centrifugal Compressor Driven by Induction Motor Through Step-Up Gear
(Test results shown in Table 1.)

r.p.m. induction motor. A study of the comparative results that is the power as found from the electrical input and that determined by the heat-balance method, will show that the difference is larger than in any of the other tabulations, the power as determined by the temperature readings being 4 per cent too low for the first point, 2.7 per cent too high for the second, and 4 per cent too high for the third. This test illustrates well the limitations of the method, as well as the extreme care required in some cases.

In this particular instance, because of the low pressure rise of the machine, the relative failure was due to the inability to determine the temperature rise of the air with a sufficient degree of accuracy. There was also the added uncertainty of the motor output at the comparatively light load, particularly in regard to the effect of the bearing friction and windage and pump loss. The encouraging feature, however, is that the power is alternately too low and too high as compared with the motor output, proving that the lack of agreement was due to poor testing conditions rather than to wrong principles. The tests on this set-up were not continued, due to the inherent handicaps existing.

Case 4 shows a point near the full load and at 77 per cent load taken on a turbine-driven high-speed compressor. The compressor was of the three-stage, water-cooled construction, and was direct-connected to the turbine. A comparison of the input determined from the heat-balance method and that calculated from the steam readings taken on the turbine again shows agreement within 2 per cent. It will be noted that the water and air horsepower are about equal, as is often the case of a relatively low-pressure machine of this type.

Case 5 is included primarily to show the energy-input distribution in the case of a high-pressure machine. The unit was a seven-stage compressor of the water-cooled construction, driven by a 900-hp. steam turbine through a single reduction gear. No attempt

TABLE 1 SUMMARY OF CHECK TESTS

CASE NO. 1

Date of test	Feb. 17, 1925				
Compressor type	Single Stage—No Water Cooling				
Driver	75-Hp. Induction Motor				
Per cent compressor load	102.8	115.0	...	...	...
Pressure ratio, $\frac{\text{discharge pressure}}{\text{inlet pressure}}$	1.22	1.21	...	...	...
Compressor hp. input:					
(a) From output of driver	82.2	89.5	...	...	...
(b) By heat balance method	80.1	88.2	...	...	...
Difference (a) and (b), per cent	—2.6	—1.4	...	...	...
Energy distribution, per cent of input:					
Air hp	97.4	97.6			
Radiation hp	2.6	2.4	...	...	...

CASE NO. 2

Date of test	Nov. 21, 1924				
Compressor type	Single Stage—No Water Cooling				
Driver	175-Hp. Gear-Driven Induction Motor				
Per cent compressor load	100.0	115.0	130.0	160.0	86.0
Pressure ratio, $\frac{\text{discharge pressure}}{\text{inlet pressure}}$	1.45	1.44	1.43	1.38	1.46
Compressor hp. input:					
(a) From output of driver	131.2	146.7	165.2	197.3	113.7
(b) By heat-balance method	128.0	145.2	165.0	196.2	113.0
Difference (a) and (b), per cent	—2.4	—1.0	—0.1	—0.5	—0.6
Energy distribution, per cent of input:					
Air hp	97.7	97.9	98.2	98.5	97.3
Radiation hp	2.3	2.1	1.8	1.5	2.7

CASE NO. 3

Date of test	Dec. 26, 1924				
Compressor type	Single Stage—Wooden Casing				
Driver	100-Hp. Induction Motor				
Per cent compressor load	55.0	56.0	70.0	...	...
Pressure ratio, $\frac{\text{discharge pressure}}{\text{inlet pressure}}$	Approximately 1.17				
Compressor hp. input:					
(a) From output of driver	49.3	50.4	63.3	...	...
(b) By heat-balance method	47.25	50.6	65.1	...	...
Difference (a) and (b), per cent	—4.1	+2.7	+4.1	...	...
Energy distribution, per cent of input:					
Air hp	100	100	100	...	...
Radiation hp	Negligible				

NOTE: Unfavorable because of (1) light load on compressor, (2) light load on motor, (3) small pressure ratio.

CASE NO. 4

Date of test	May 21, 1924				
Compressor type	Multi-Stage—Water Cooled				
Driver	2 Stage Steam Turbine				
Per cent compressor load	77.0	100.0	...	...	...
Pressure ratio, $\frac{\text{discharge pressure}}{\text{inlet pressure}}$	1.65	1.70	...	...	...
Compressor hp. input:					
(a) From output of driver	269.5	326.3	...	...	...
(b) By heat-balance method	274.7	329.7	...	...	...
Difference (a) and (b), per cent	+1.9	+1.0	...	...	...
Energy distribution, per cent of input:					
Air hp	51.6	59.5	...	...	...
Water hp	45.0	37.7	...	...	...
Radiation hp	0.8	0.7	...	...	...
Bearing and gear loss hp	2.3	1.9	...	...	...
Packing loss hp	0.3	0.2	...	...	...

CASE NO. 5

Date of test	Feb. 26, 1925
Compressor type	Multi-Stage—Water Cooled
Driver	Steam Turbine through Reduction Gear
Per cent compressor load	110.0
Pressure ratio, $\frac{\text{discharge pressure}}{\text{inlet pressure}}$	5.91
Compressor hp. input	982.0
Energy distribution, per cent of input:	
Air hp	25.9
Water hp	68.9
Radiation hp	0.6
Bearing and gear loss hp	4.6
Packing loss hp	0

CASE NO. 6

Date of test	Nov. 5, 1925				
Compressor type	Single Stage—No Water Cooling				
Driver	145-Hp. Induction Motor				
Per cent compressor load	112.8	102.3	90.0	73.5	109.2
Pressure ratio, $\frac{\text{discharge pressure}}{\text{inlet pressure}}$	1.17	1.17	1.17	1.17	1.25
Compressor hp. input:					
(a) From output of driver	206.0	190.9	172.8	146.5	345.0
(b) By heat-balance method	208.7	191.6	171.1	145.5	345.6
Difference (a) and (b), per cent	+1.3	+0.4	—1.0	—0.7	—0.2
Energy distribution, per cent of input:					
Air hp	98.5	98.3	98.0	97.7	98.7
Radiation hp	1.5	1.7	2.0	2.3	1.3

was made to calculate the turbine output directly for a check, because the unit was not operated under the rated steam conditions. It will be noted that the water horsepower represents about 70 per cent of the total input, showing that in high-pressure multi-stage water-cooled machines the water hp. is the item of major importance.

Case 6 refers to a 145-hp. motor-driven set of the same general type as Case 1.

CONCLUSION

The tests reported in the preceding paragraphs show agreement between the power input to the compressor as measured by the heat-balance method and that determined from drivers of known efficiency, usually within 2 per cent. With the progress of the art, i.e., more skill and the adoption of instruments suitable to each type of machine tested, more reliable results are being realized. Too much stress cannot be placed on the absolute necessity of using proper testing equipment, i.e., instruments sufficiently precise for the particular set of conditions. As a general rule, the low-pressure (and hence small-temperature-rise) machines are the most troublesome, as is exemplified by the test on the wooden model compressor. On the whole, after an experience of over two years and after careful study of all the relevant matter, the author believes that the heat-balance method of testing, being inherently sound thermodynamically, is simple to understand and to explain, is economical when the expense involved is compared with that of any other means of ascertaining the power supplied to a compressor (except in the case of motor-driven sets with no intervening gear train), and should commend itself to a more widespread use.

The old objection to any calorific method as giving "too low" a power input is no longer founded on facts, as shown by the tests cited where both positive and negative differences occur. This criticism was overcome primarily by using a properly increased value of c_p, sufficient care in measuring temperatures, and due allowance for the heat lost from the casing. With reliable equipment and due caution, satisfactory results can be obtained from about 80 per cent load and over. At the lighter loads, the degree of certainty will depend upon the engineer's ability to establish the exact magnitude of the "constant" losses, that is, those due to emissivity from the casing, to bearing friction, and imperfection of the packings.

Discussion

THE discussion of Mr. Robinson's paper was opened by the reading of an important written discussion by A. Peterson[4] who said that the paper was, so far as he knew, the first publication in the English language covering the heat-balance method of testing centrifugal compressors. As the author said, this method had been used abroad. Incidentally it was rather completely described in Ostertag's book on Kolben- und Turbo-Kompressoren, which also gave results of tests, the heat-balance method agreeing very closely with other accurate means of measuring the output from the driver. The company with which the Mr. Peterson was identified had used this method of testing centrifugal compressors as far back as ten years ago, with very satisfactory results.

In estimating the power input to the compressor the author had neglected to take into account an item which on high-pressure compressors did not amount to much, but which on low-pressure blowers might affect the results quite materially. This item was the energy in the air or gas in the form of velocity. For instance, if there were a velocity of 100 ft. per sec. in the discharge pipe of a blower for 2 lb. per sq. in. pressure, the velocity head was approximately 0.089 lb., so that an error of practically 4.5 per cent would result if the velocity energy were neglected. The method of testing blowers and compressors for efficiency as described by the author could only be used when means were available for measuring the volume delivered. Where it was not possible to obtain the volume, the efficiency for uncooled compressors could still be calculated approximately from only the temperature rise by means of the formula

$$\eta_{ad} = \frac{t_{1/2} - t_1}{t_2 - t_1}$$

where

η_{ad} = efficiency based upon adiabatic compression
t_1 = initial temperature
$t_{1/2}$ = theoretical end temperature based upon adiabatic compression
t_2 = actual end temperature.

[4] Engineer, De Laval Steam Turbine Co., Trenton, N. J. Mem. A.S.M.E.

With this method allowance also had to be made for radiation, leakage, velocity energy, etc., and it did not apply to water-cooled compressors. Suction and discharge pressures naturally had to be known when the above method was used.

These items were not given exactly in the author's test, but assuming that the figures for compression given in Tables 1 and 2, Appendix No. 2 of the complete paper, represented fairly closely the discharge pressure for 100 per cent load, an approximate check could be made. Taking, for instance, test No. 1 in Table 1, 3 lb. discharge pressure and 14.7 lb. absolute inlet pressure gave a theoretical temperature rise based upon 71.34 deg. fahr. inlet temperature, of 28.7 deg. fahr. The actual temperature rise being 44.22 deg. fahr., the adiabatic efficiency was

$$\frac{28.7}{44.22} = 64.9 \text{ per cent.}$$

The theoretical air horsepower was obtained from formula (*a*) in Appendix No. 1, using $T_d - T_i = 28.7$. The theoretical air horsepower was 50.7, giving an actual air horsepower of $\frac{50.7}{0.649} = 78.1$, as compared with 78 by the author's method. The agreement between the two methods was accordingly very close.

While the method just described did not permit of estimating the power input to the blower unless the volume were known, it might, however, be of value because in the majority of blower installations, where no means were available for measuring the volume, it gave the engineer a means of estimating the approximate efficiency of the machine without much trouble and expense.

Sanford A. Moss[5] opened the oral discussion of the paper and pointed out that the method described was not new, but that early users of the method had either made inaccurate allowances for the radiation horsepower or had made no allowances at all. In such early work erroneously high values of efficiency were obtained, errors ranging from 5 to 10 per cent. The fact that a compressor had an appreciable radiation was shown by the fact that it could actually be operated at no load with an appreciable power input, while there was no heat discharge in the air because no air was discharged. Under such conditions there was nevertheless only a moderate rise in the temperature of the compressor casing, showing that there was a definite amount of radiation. Dr. Moss thought that the author was the first person to take measurements with the necessary precision and to take all factors into account, in this method.

W. H. Carrier[6] said that in the centrifugal compressors used in refrigeration there was an evaporator which gave a definitely measured quantity of gas, known from its latent heat and the quantity of water being cooled, measured as accurately as possible. The heat extracted thus was known and the corresponding quantity of gas given off at an accurately measured pressure could be determined. Since there was a definite temperature for this gas and a sufficiently large volume, very little change of temperature was possible, due to radiation. Allowance could be made for such radiation as occurred, and the temperature of the discharged gas could always be ascertained very accurately. The quantity of heat extracted in the condenser could also be measured with great accuracy. The difference between the two quantities was the power input. If the measurements were carefully enough made, this difference in heat extracted did measure the power load with great accuracy. The temperature rise of the gas and the quantity of gas as measured with the orifice method or the pitot-tube method, gave the other check. If in addition the power input were measured, there were three entirely independent methods of check.

The author in his reply to Mr. Peterson's statement that in low-pressure blowers there was an error due to the omission of the energy increase due to flow, thought that in reality no such error was involved, for the following reasons: In the case of a low-pressure unit the inlet pipe and the discharge pipe were practically the same size and the effect of the velocity on the temperature-measuring devices was exactly similar, that was, a considerable velocity of the air stream simply acted to give an indication of the dynamic temperature instead of the static temperature of the jet. In this way there was really no error involved. With regard to Professor Ostertag's book, he thought that the method was not described in sufficient detail in this text to be readily usable, and he also questioned the radiation constants given. Referring to Mr. Peterson's scheme of getting at the efficiency of a low-pressure unit by assuming the discharge temperature as adiabatic, Mr. Robinson believed that this would work quite satisfactorily as an indication of the performance of the machine, but did not believe that as close a check would be thus obtained as by taking proper account of all the variables involved.

[5] General Electric Co., West Lynn, Mass. Mem. A.S.M.E.

[6] President, Carrier Engineering Corp., Newark, N. J. Mem A.S.M.E.

Photomicrography

PHOTOMICROGRAPHY, or the science of photography under high-power microscopes, has been highly developed by R. G. Guthrie of Chicago, as indicated by the fact that he has successfully enlarged and photographed the structure of a piece of steel 15,500 diameters in a single projection. Such magnification is so tremendous that only objects invisible to the naked eye can be dealt with in order to be able to get the enlarged image on a photographic plate. The significance of this enlargement is emphasized by the fact that if the head of an ordinary pin about $^3/_{32}$ in. across, were magnified to this extent it would become 116 ft. in diameter. If the face of a coin, say, a quarter, about 1 inch in diameter, were increased 15,500 diameters, it would stretch out nearly one-quarter of a mile. This combination of lenses, which may be said to form the sharpest eyes in the world, is capable of separating and photographing lines lying so close together that 200,000 of them are contained within a single inch.

In obtaining this remarkable magnification of practically invisible quantities, a vibration of as much as $^1/_{250,000}$ in. would have made results impossible. One important difficulty lies in focusing the almost infinitesimal extremes in measurement that the work entails. The laboratory in which this work was done is located on the seventeenth floor of a building which covers nearly an entire block. This work necessitates such extreme accuracy that it can only be done at night when there is little traffic passing on the streets over two hundred feet below, for even the passing of a truck on an adjoining thoroughfare is sufficient to jar the photomicrograph or metallograph out of alignment.

The apparatus used in carrying out this work, a Leitz micrometallograph, consists essentially of a very high-power microscope arranged between a powerful automatic arc light and an extremely fine camera, the entire apparatus being mounted on a carriage suspended on sensitive springs so that even a slight movement of the floor will not disturb it. The outfit is about 7 ft. long, the camera bellows having an extension of $3^1/_2$ ft. One of the adjustments on the metallograph is a dial reading to 0.025 in., arranged so that it can be read up to 0.050 in. A movement of as much as one of these units is sufficient to spoil the photography at high magnifications. When it is remembered that exposures with a high-power arc light take from thirty minutes to one and a half hours in order to make a picture of a sample, and that even the slight vibration of a twenty-story skyscraper is sufficient to spoil a picture, the difficulty of this work will be appreciated.

The sample to be examined is very small. It need be no more than a tiny fragment, though a piece about an inch in size is preferable for convenience in handling. This is placed on a small platform above the microscope over a tiny hole illuminated by a strong arc light. The image of this exposed spot then passes through the lenses of the microscope and camera where it is finally photographed. Before this is possible, however, elaborate preparation of the sample is necessary in which cleanliness and accuracy are vital. (From an article on Steel Magnified 15,500 Diameters, by Fritz Blocki, in *Machinery*, Feb., 1926, pp. 447–449.)

According to a recent German invention tar containing water is treated with a sufficient quantity of a neutral salt, such as magnesium chloride, magnesium nitrate, ammonium nitrate, excluding calcium chloride, to form a moderately concentrated solution with the water present. The whole is stirred mechanically at about 70 deg. cent., and when agitation is stopped rapid separation into a top layer of tar and a lower layer of salt solution follows. *Engineer*, Jan. 22, 1926, p. 99.

Opportunities for Engineers in Industry

The Necessity of Advising the Preparatory-School and Engineering-College Graduate about the Duties, Opportunities, and Responsibilities of the Engineer, so that He May Make A More Intelligent Choice of His Profession

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FREDERICK W. TAYLOR prefaced his paper on scientific management with the statement that the object of management should be to secure the maximum of prosperity for the employer coupled with the maximum of prosperity for each employee.

The truth of this statement is undeniable, and in discussing the possibilities of developing a more scientific method for adapting technically trained men to the industries, we may assume that no method is perfect which does not further the best interests of every one in any way affected by its operation. Such an ideal is, of course, not possible of complete attainment, but the principle holds, and the measure of our success must be the nearness of our approach to this ideal.

With this in view let us consider for a moment how far we have fallen short in the development and placement of our young engineers.

The demand for technical education is increasing, and facilities are strained to the utmost, and yet in the freshman classes of all our schools are men who will never be graduated and who will probably not survive the freshman year. What is the cause of this? The usual reply from those responsible for the conduct of our colleges is to lay the blame on the preparatory institutions. As far as satisfactory preparation is concerned this may be justified, but as thousands of men with such preparation do get through, it is doubtful whether there is anything in our preparatory system which will prevent the average student from being graduated if he really wants to be. The trouble is that he has very little opportunity of finding out just how sincere is his desire for an engineering education. Both the high-school and the college graduate are confronted with the necessity of making a choice as to their next step. This choice is of the utmost importance to them and should be based upon reliable information. Many a man would not consider an engineering career if he could learn more about the conditions before he started, and many a man would find himself engaged in work better suited to his abilities and inclinations if he had more reliable information as to the possibilities.

The young engineering graduate is often criticized as having an exaggerated opinion of his value to an industry, but any one who will really take the trouble to discuss their personal problems with a representative number of these young men, will be compelled to admit that however faulty their views may be, the trouble is seldom due to an exhalted idea of their own inherent virtues. If they enter the industries ignorant of the conditions and their proper relationship to them, it is our fault rather than theirs. Many of these young men find themselves working under conditions which are quite different from what they had anticipated; their perfectly natural hopes and ambitions appear to be frustrated, and they lose heart and are content to struggle along as best they may. Nothing could be worse for the reputation of the engineering profession than this.

A man goes to college to obtain the necessary tools to use in his profession. While he may be taught a little about the elementary use of these tools, he cannot be made skilful in their use in four or five years. If this is so, who is going to finish the job which the colleges have begun? Obviously, this must be done in the industries, and if it is to be done with any degree of economy and efficiency, it cannot be done in a hit-and-miss fashion, as is generally the case at present.

The old-fashioned apprenticeship system is, no doubt, to a great extent unsuited to present requirements, as far as professional engineers are concerned, but it recognized a definite need and filled it in a consistent and definite way. Today we have nothing to replace it except a few cadet courses given by some of our more progressive concerns, and aimed chiefly at the production of men suited to their own particular needs.

At the present time there is not, as there was in earlier days, a universal recognition on the part of the engineering industry as a whole of its obligation to provide proper training for engineers. We are passing the responsibility to the colleges, and then grumbling because they are not equipped to turn out the finished product which we require.

Perhaps our present system would be fairly satisfactory if we could furnish to young graduates reliable guidance for their future development, and if industry would recognize more generally its moral obligation to provide adequate opportunities for these young men to complete their training.

The Engineer as a Draftsman

It might reasonably be asserted that every engineer should be a competent draftsman, that is, he should be able to do his own designing, and understand the requirements of good drafting-room practice. If this is true the drafting room should be in direct line of promotion, but evidently in many cases it is not.

No doubt there are some draftsmen who have fairly good jobs and prospects of promotion. Too often, however, drafting proves to be a dead-end job, and there is little doubt that the graduate engineer who starts in the drafting room runs a serious risk of delaying his ultimate progress.

The Engineer in the Machine Shop

Possibly no branch of engineering offers a larger range of opportunities for the employment of trained engineers than that of machine-shop practice and management. Moreover if we should agree, as undoubtedly we shall, that the college cannot turn out finished engineers, and that the theoretical training received there should be supplemented by a well-planned course of practical work, it is to the managers of the machine shops that we must look for coöperation in solving this very important problem.

The important question, however, from the standpoint of this discussion is not so much where are the jobs, but to what do they lead. At present the answer is far from being clear. There is no doubt that the machine shops can find room, at a reasonable remuneration, for a certain number of men, who, for want of a better name, we may call "mechanical experts." At the same time it would appear that the most promising opportunities for advancement are in the fields of organization and management, and the engineer entering upon duties of this nature will find that instead of analyzing his problems in terms of stresses and strains or thermal efficiencies, he will be called upon to analyze them in terms of dollars and cents and human reactions, which he has probably come to believe are not engineering terms at all.

In spite of a lot of pseudo-scientific teachings to the contrary, he will find also, if he has the insight to see it, that, in dealing with men, moral and spiritual values have greater weight than purely material and mental ones, and if he is to fill his position as it ought to be filled, he must recognize the fact that the engineer as a man must be greater than the engineer as an engineer.

The Engineer in Public Utilities

The phenominal growth of electric, gas, and street-railway service in the last two decades has created a wide demand for engineering ability, not only in purely mechanical, electrical, and structural lines, but in other branches, which, though perhaps not strictly of an engineering nature, are so highly specialized and technical that they are best served by men who have had an engineering training.

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There is possibly no other field in which there are greater opportunities for permanent employment and orderly promotion, and to a man who is seeking such conditions, it offers an attractive career; but these very conditions indicate the advisability of making a most thorough canvass of other lines of employment before finally deciding to enter the public-utilities field.

For one who does not care for permanency of employment or a specialized career, the public utilities have perhaps little to offer; on the other hand, the range of their activities is so broad and varied that many widely different types of men can be taken care of.

The Engineer in Railroading

The practice of the railroads in the past has been to a large extent to ignore the college man. However, in recent years some of the lines have indicated a change of policy, and are not only employing college men but are providing special apprentice courses for them. Apprentice courses such as that of the Pennsylvania Railroad may be for three years; this road gives a thorough training in machine-shop practice as it is met with in railroad shops.

Railroading always has appealed to the type of man who is more interested in a good practical job and a stiff fight than in school books, but a practical man of this type backed by a sound theoretical training should go far, and the possible rewards are at least as great as in other fields of engineering. At the same time, as in many other cases, the line of eventual promotion is rather away from engineering, but even so, engineering affords a very sound base from which to start on one's journey.

In a railroad organization the claims of seniority must be given careful consideration, and there is not much chance of exceptionally rapid promotion, except in isolated cases. The rewards, however, of those who stick to the game and have a reasonable amount of good fortune are not inconsiderable, and it may be worth while for college men to give more attention to this line of work than they have generally done in the past.

The Engineer as a Salesman

In the sale of engineering equipment, technically trained men are now generally employed. The field is wide and affords one of the few possibilities which still exist for the engineer to establish himself in business in an independent or semi-independent way. However, opportunities for this are somewhat limited. In considering this field there are some special points which should be given careful attention.

Although at first sight it might appear that selling should provide some useful experience for the engineer, which it undoubtedly does, at the same time there is a danger that to a certain extent it will unfit a man for the routine practice of his profession. In the first place, the independence of judgment which it is necessary to cultivate if a man is to give his best service in a professional way is an impediment to the salesman. Perhaps some will not admit this, but in these days when every line of equipment is represented by a number of reliable manufacturers, the task of deciding which is the best is no slight one; in fact, in many cases there probably is no best, but this is something which the salesman must not admit to his prospect, and if he is wise he will not admit it to himself.

The salesman is generally less confined by routine than other engineers—to a large extent the use of his time is often left to his own judgment; he has to mingle freely with other men, and is sometimes called upon to hide business under the guise of pleasure. To the right type of man this is very attractive, but it is hard to break away from if later he should decide to take up purely engineering work. On the other hand, salesmanship, perhaps as often as any other line, leads to an opening in the ranks of the higher executives.

In addition to those engaged in the selling of mechanical equipment there are a number of technically qualified men engaged with contractors who are often classed as estimators. In the case of the smaller firms, the estimator is sometimes business getter, estimator, and engineer in charge of the work. In fact he often takes the place of the head of the business. This line of work offers good opportunities for gaining experience, especially in the line of heating and power installations. Unfortunately, however, the widest experience is generally gained with the smaller concerns, and with the larger companies the activities of any one man are likely to be more circumscribed.

Although we hear a great deal of lamentation about the disappearance of the all-round man, when such a man does appear it is seldom that any one wants to pay a good price for his services. In the case of the workman or the mechanic there is no place for him on a union job, and the unions will not let him work as such; in the case of the engineer, it is as a rule only the smaller concerns who will employ a man in an all-round capacity. Ninety per cent of the advertisements for engineers wanted call for men who are, to a limited degree at least, specialists along a certain line.

Of course an engineer cannot have too wide an experience, but we must face a condition and not a theory, the condition being that this is an age of specialization, and with the high labor costs prevailing in this country it is only by specialization that we can compete with the rest of the world.

This is a matter to which sufficient consideration has not been given in connection with the training of our engineers and it is one which presents a very difficult problem. We all feel that the engineer should be an all-round man of wide general experience, but if the industries insist upon asking for specialists, what course should we take? This is not a question which can be answered offhand. We find this tendency in all professions. In law and medicine the general practitioner is losing caste and the specialist is getting all the plums. Engineers are facing the same condition. At present efforts are being made to counteract the effects of too much specialization. At the same time we must face the facts, and if we find that unescapable economic conditions demand a high degree of specialization, we must prepare ourselves accordingly.

The Engineer as a Business Man and a Citizen

A very important point which is often overlooked by engineers is the fact that much so-called engineering is not, strictly speaking, engineering at all, but business. Members of other professions often recognize a similar condition as applying to them, and we find, for instance, lawyers not only making our laws but running our businesses. If an engineering training does not fit a man to control the affairs of his own business, and also to take his place in the government of his country, there is something radically wrong with it. In all probability failure in this direction is attributable more to faulty psychological conditions than to faulty technical education.

Unfortunately opportunities for the engineer to make a living in any other capacity than as an employee of a company are decidedly limited. He expects to take a job and confine himself strictly to that job, and the profession as a whole is suffering from this attitude. It is true that matters are gradually improving, but the future is in the hands of these young men whose welfare we are chiefly now considering, and the engineering profession will miss a great opportunity if it fails to offer them every encouragement to train themselves to take a leading part in the affairs of business and of the nation.

In Conclusion

The criticism may be made that possible opportunities for the employment of engineers should have been more definitely listed and described, but any attempt to do this has been purposely avoided. Data based upon the experience of one man, or a limited investigation, do not afford an adequate foundation for the very important decisions involved. If the work of providing this information is not undertaken with a proper appreciation of the task and its serious responsibility, it had perhaps better not be done at all, and yet the demand is so clear and persistent that it would seem that it must no longer be delayed. If this paper should succeed in establishing that fact, it will have served its purpose.

Erratum

IN THE February issue of MECHANICAL ENGINEERING on the Contributors' page it is stated that Mr. Thomas D. Perry was vice-president and general manager of the Grand Rapids Veneer Works from 1911 to 1925. Mr. Perry was appointed to that position in 1919.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS (See also Internal-Combustion Engineering: The Blackburne Thrush Light-Plane Engine)

The Ford Air-Transport Program

COMMERCIAL aviation has actually arrived in the United States and will make great strides during the coming year. In 1925 the Stout Metal Airplane Co. built fifteen Stout air transports, and at the end of the year it reached a production of two a month. This production will be increased during 1926 to one plane a week of the large transport type. Production is now being started on the trimotor plane, which has three engines, each of 200 hp., or a total of 600 hp. These planes have a capacity for carrying twelve passengers with hand baggage, or a ton of express or freight.

The safety and practicability of air transportation have been demonstrated during 1925. For nine months there has been regular daily service between Chicago and Detroit, three single trips being made daily. For six months service has been maintained between Detroit and Cleveland, in all kinds of weather, and on only one day were the scheduled trips cancelled because of a fog so dense that not a single steamship went through the Detroit River for eighteen hours.

In the services mentioned no accident of any kind has occurred, although an equivalent of 2,000,000 passenger-miles has been accomplished. During 1926 this service will be placed on a regular commercial basis, and it will be possible to carry passengers from Detroit and Chicago for $25, and from Detroit to Cleveland for $15. Ultimately, when the volume of traffic increases, it will be possible to carry passengers by plane as cheaply as by rail.

During the coming year regular passenger lines will be placed in operation between Los Angeles and Salt Lake City, Los Angeles and Dallas, Tex., Chicago and Dallas, and Boston and New York. Three or four lines will also be placed in operation in Florida. The Stout Metal Airplane Co. has sold all the planes it can build up to next July for definite lines, planes being sold only to corporations who intend to use them for commercial purposes. No planes are sold to individuals. (Wm. B. Stout, Pres., Stout Metal Airplane Co., Division of Ford Motor Co., Detroit, Mich., in *Machinery*, vol. 32, no. 5, Jan., 1926, p. 35*d*)

The Super Rhone Engine

DESCRIPTION of a nine-cylinder radial air-cooled engine rated at 120 hp. at a normal speed of 1400 r.p.m. and designed for use on small commercial airplanes. It is built upon the base of the Le Rhone rotary engine which was manufactured in this country during the war by the Union Switch and Signal Company for the War Department.

In the new engine are used many parts of the old rotary, the entire surplus of which was bought from the Government at a small fraction of the original cost. The engine has a taper-jointed counterbalanced crankshaft of single throw, which makes it possible to completely disassemble it in 30 min. time. Fresh air is admitted under atmospheric pressure to the crankcase, and a complete change of air within the crankcase is accomplished with each revolution. This is said to eliminate excessive accumulation of heat at the center, and by regulation of temperature and pressure to reduce oil consumption to a minimum.

The engine mounting, which also serves as an intake manifold, is a strong, clean aluminum casting of tested strength. It carries, on its rear and lower side a flanged-face opening to which the carburetor is attached, and from which opening the explosive gases are carried to a central chamber from which they are conducted by individual ducts in the periphery of the casting where the intake pipes that lead to each cylinder are fastened. Thus each cylinder draws its gases as needed from this central chamber, eliminating thereby the excessive amount of gas in any one cylinder which is the most frequent cause of fouling in air-cooled engines and is often attributed to lubrication faults. This engine mounting has two properly surfaced flanged extensions toward the rear, 2 in. wide and 13 in. long, which form the means of fastening the engine to two engine beds as is the practice in water-cooled types. This cheapens installation costs by the elimination of expensive circular mounting brackets, and readily adapts the engine to installation in the usual manner. The engine mounting also carries the magneto and oil pump and the scavenger pump, and it is to be noted that the engine proper may be withdrawn from this mounting without disturbing fuel, oil, or electrical connections and controls. (*Aviation*, vol. 20, no. 4, Jan. 25, 1926, pp. 113, 1 fig., *d*)

McCook Field Altitude Biplane

DESCRIPTION of the XCO-5-A of the Engineering Division, McCook Field, designed for high-altitude flying. The type of wings selected to give the desired high lift was the Joukowsky StAe-27A. A set of wings to this design was built in the Engineering Division shops. Of wood and fabric construction, they are heavily cambered, being extremely thick at the leading edge and tapering sharply to the rear. It is intended to use a detachable-blade aluminum-alloy propeller 10 ft. 6 in. in length with pitch adjustable on the ground.

In former flights a temperature as low as 82½ deg. below zero fahr. has been encountered. To further protect the pilot from the extreme cold, an extra heating apparatus has been mounted on the exhaust manifold on the left side of the plane so that the cold air passing over the hot manifold and becoming heated is led through a tunnel and thence into a flexible conduit which, extending in the interior of the cockpit, ends near the control stick. In this way the warm air will be directed to the pilot's hands and the center part of his body. However, because the conduit is flexible, he may change that direction as he chooses. Dampers in the tunnel make it possible to keep the temperature from becoming too warm at the lower altitudes, a danger which will not exist higher up.

The XCO5 is powered with the 400-hp. Liberty engine. A submerged fuel system has been adopted for altitude work; that is, the fuel pump has been placed at a level lower than the gasoline tank, thus accomplishing gravity feed from tank to pump. At high altitudes, the boiling point of fuel is reduced close to its vaporization point. Therefore, any added negative pressure imposed on the fuel by its lifting to the pump, is apt to cause vaporization, in which condition it is impossible to pump it to the engine. By submerging the pump beneath the level of the tanks, the duty of the pump is reduced to merely discharging the fuel, which, backed by an even gravity pressure, more easily retains its normal liquid condition. The regular Liberty starting system has been removed and an 8-volt ignition system installed to lighten the plane for these tests.

The question of supercharging has been given particular attention. In former supercharger installations much difficulty was experienced with preignition of the engine. This often became so pronounced that the plane had to be brought to earth. It was suspected that a richer mixture with supercharger at altitude was necessary. This was found to be true, but the principal difficulty was the overheating of the mixture due to the heat generated in the supercharger itself. Due to the increase of temperature created by the compression in the supercharger, it was necessary to interpose an intercooler between the supercharger outlet and the carburetor in order to obtain satisfactory engine performance. The intercooler, in the form of a honeycomb radiator, was placed on the side of the airplane. It was also found that, owing to poor conductivity of the air at high altitudes, additional radiating surface for engine cooling was required. This, with the correction of mixture, put an end to preignition.

An altitude record is not the prime object of these tests, while the development and testing of altitude equipment for military purposes is of the utmost importance. Experiment has brought to light that actual combat will scarcely be waged above 25,000 ft., the mental and physical faculties of man being too subnormal above this height for quick and efficient accomplishment. With the development of accurate bomb sights, bombing can be carried on as high as 30,000 ft. as less energy is demanded for bombing than for the more strenuous operations of pursuit combat. Photographic work may be accomplished, however, as high as 35,000 ft. Pictures of great areas, made at this height near McCook Field and enlarged, have proved to be remarkably clear in detail. Such views over enemy territory would be of untold value for war purposes. The plane would be out of sight and hearing of those on the ground and beyond the range of anti-aircraft gun fire. Hence, it is most important that altitude experimental work about 35,000 ft. levels be most ably pursued. (A. M. Jacobs in *Aviation*, vol. 20, no. 2, Jan. 11, 1926, pp. 52–53, 1 fig., *d*)

The Development of the Autogyro

WHILE many descriptions of the autogyro recently tested at Farnborough, England, by the British Air Ministry have appeared in the American press, none of them has been complete enough to indicate the real difficulties which the designers had to overcome and the engineering problems involved.

The first idea of the machine was one provided with a windmill on a vertical axis driven solely by the relative wind, a component of which, parallel to the axis, was to be obtained by beating the wings as in an ornithopter. This design remained on paper, for very soon it became clear that a lifting windmill of this kind would turn without any flapping action, provided the axis was slightly inclined backward from the vertical.

The chief difficulty of this arrangement was the lack of symmetry of lift on the wings, for the wings rotating against and with the relative wind would have their average velocities through the air respectively increased or decreased, with a corresponding asymmetry of lift and displacement of their resultant lift from the vertical, leading to a sideways movement and ending possibly in a side slip.

The first autogyro was therefore built with two windmills of four blades each on the same axis, but turning in different directions. The revolution counters fitted to each windmill indicated that in the case of the upper windmill there was a satisfactory agreement with previous calculations, but the lower windmill ran at only two-thirds of the expected speed, with consequent lack of compensation of the lateral forces. While a differential gear could have been employed to impose equal rectangular velocities mechanically, this would have increased the already considerable complication of machinery and mechanical losses. It was therefore decided to attempt to compensate the greater relative speed of the upper blade by a small relative incidence in elements diametrically opposite. It was believed that if it were possible to choose the aerodynamical characteristics of each element and to control its incidence so that the resultant lift couples of the opposed blades should be in equilibrium, the problem would be solved. The detailed computations were laborious, for the compensation must be effective at all incidences.

After innumerable trial solutions, the second type of autogyro was built, consisting of a single windmill with the cantilever blades capable of being set at varying incidence by the pilot, who could thus displace the resultant lift to right or left at will.

When taxying at the airdrome the machine developed the calculated angular velocity of the windmill and an adequate lift, but as soon as the pilot brought the machine into the appropriate attitude for flight, it inclined toward the wing which was rotating contrary to the direction of flight. It followed that the distribution of pressure did not occur in accordance with the preliminary assumptions and calculations. In the course of this work the machine was reconstructed nine times. It appeared that the discrepancies could be accounted for by torsion of the unbraced cantilever blades, which had not sufficient torsional rigidity to withstand twist, and consequent change of effective incidence caused by shift in the center of pressure. These torsional forces evidently alternate with each complete revolution.

The third type of autogyro designed was based on the same general principles, but with heavy bracing of the blades to the axis by streamline high-tensile steel wires as in airplane practice. This machine showed a closer approach to lateral balanee than the normal, but still had a tendency to fall over sideways, which an elevator divided into two independent parts—right and left—was insufficient to control. It was damaged and rebuilt four times in the course of the experiments.

It was not until the beginning of 1922 that the use of articulated blades was resorted to and gave a complete solution of the problem of stability. In the Autogyro Type 4 there was provided a single windmill with four rotating blades, but instead of being rigidly attached they were hinged near the root (in the latest designs the hinge pins are at 2 deg. with the axis of the windmill). The blades were thus able to move freely about their hinges, beating the air, so to speak, freely without any sensible change in their geometrical incidence, the chord remaining always practically parallel to its original position for small amplitudes of beating movement. In rotation centrifugal forces act on the blades and are large enough to keep them nearly perpendicular to the axis. By the construction the resultant force acts at point in the axis above the hinge pins.

Since the blades are articulated the total reaction on each blade, that is, the resultant of all the air forces and inertia forces acting on it, must pass through the hinge pin. Perpendiculars drawn between hinge pins and axis meet in a common point on the axis. Since these perpendicular distances are small the resultant of the four-blade reactions may be taken as active at this "common point." This resultant is in general inclined slightly to the axis, and by giving an equal and opposite inclination to the axis the result becomes vertical. If the center of gravity is below the "common point" the airplane is in equilibrium, in spite of the asymmetry of the forces on the blades. The "common point" may be called the metacenter of the air forces and inertia forces on the blade system. It is nearly independent of incidence, speed, etc.

The center of gravity is relatively very low, hence there are always high restoring forces bringing the machine back to its position of equilibrium. At the same time there are high damping forces preventing resonance, i.e., oscillations of increasing amplitude about the position of equilibrium, as might be feared from the low center of gravity. The damping does not, however, interfere with ordinary maneuvers. Gyroscopic forces, which would be of the severest nature in a rigid system, cannot be transmitted through the flexible attachment of blades to axis. Finally, the articulated blades form a flexible system in sudden gusts. The inertia forces are ten times the lift forces, the resultant being $\sqrt{(10^2 + 1^2)} = 10$ very nearly. In a gust producing ten times the air forces the resultant would be $\sqrt{(10^2 + 10^2)} = 14.1$ approx., an increase of only 41 per cent over normal stresses.

In the first machine of this type lateral control was provided for by tilting the axis of the windmill, but it became immediately evident in the very first tests that the pilot's strength was insufficient to work the control. The axis was then fixed rigidly and the machine provided with two small non-lifting ailerons at the end of streamlined spars. This gave the machine substantially the main features that it has now. Thus far six types have been built, which gives a total number of 32 distinct machines built and tested in order to arrive at the present results.

The discussion brought out a number of points which cannot be abstracted because of lack of space.

Professor Bairstow pointed out that he was greatly impressed by seeing the autogyro come down some hundreds of feet at an angle of 60 deg. and then run forward only a few yards. That, of course, is the feature of the autogyro on which most stress has been laid, and that seems to be its chief merit. Although the complete aircraft can go forward at 20 m.p.h., in still air the tips of the screw themselves are moving at 150 to 200 m.p.h.—depending a little of the condition of flight. Consequently one can see in that fact a reason for very high-lift coefficients and the very high wing loading of 25 lb. per sq. ft. without departing from a knowledge of the existing aerofoils today or the necessity for assuming new and unexplored types of air flow. If an aerofoil is to be used at all with the normal types of air flow, it must have a limiting value to the ratio lift-drag which is not at the choice of the inventor and

which is available for the airplane. The work done in moving the aerofoils under best conditions is proportional to the distance they move, and the airplane in going straight from point to point does least work. The coiled path of the aerofoils of the autogyro screw is much larger, and as a necessary consequence the device must be less efficient at high speeds than the airplane. It should, perhaps, be pointed out here that high-speed airplanes do not fly at their best angle of incidence and that the restriction may not apply to the autogyro. On the other hand, the autogyro has still to achieve speeds in excess of 70 m.p.h.

In the construction of this machine one can but admire the extreme mechanical simplicity of all its parts. The hanging of the blade screws at the central hub, the bending of the blades so that there is tension only along the spar, are admirable devices for avoiding stresses not only in the screw but in the aircraft generally.

It seems to be one of the rare occasions when nature has presented gifts to the inventor. A screw is produced which autorotates and is free from high stresses. It proves to be very stable, and the flapping essential in the stress problem does not adversely affect the aerodynamic behavior. There are, however, some gifts withheld as usual; the possibility of hovering or of rising vertically from the ground does not come with the device as exhibited.

Sir Sefton Brancker, of the British Air Ministry, called attention to the fact that apparently even a poor pilot can handle the autogyro. He also made the following statement, so significant that it is reproduced verbatim:

"This invention has caused a certain amount of despondency and alarm among some of our designers and constructors. It certainly is rather disturbing to have this completely new idea thrust upon us. We have most of us been sceptical about the helicopter, and here suddenly we have a machine which does practically everything that the helicopter sets out to do with the exception of vertical climb."

In reply to questions, the following information was supplied by the author of the paper. In answer to general queries as to area, rotational speed, and loading of windmill blades, by nearly every speaker: Blade area = $5.5 \times 0.75 \times 4 = 16.5$ sq. m.; total mass, 900 kg.; blades $40 \times 4 = 160$ kg.; loading = $900/16.5 = 54.5$ kg. per sq. m.; available power, 90 hp.

The maximum flying speed at 90 hp. was about 30 m. per sec. or 108 km. per hr. The slowest flying speed was about 15 m. per sec. The landing speed with descent at 30 deg. was about 4 m. per sec. horizontal, 2 m. per sec. vertical, the disk being nearly horizontal and therefore about 30 deg. to flight path. In vertical descent the speed was about 3–4 m. per sec., the disk being nearly perpendicular to the vertical-flight path. The angular velocity remains about constant at about 130 r.p.m. This is due to the condition that there is no torque transmitted by the shaft, which runs freely on its bearings. The total weight is also constant and the root-mean-square speed is nearly constant, hence the r.p.m. remain nearly constant.

With regard to Mr. Locke's question as to stopping at small disk incidence, this implies very high power and very high forward speed. There should be no serious difficulty with any probable horsepower and speed range. With regard to climb, rate of climb depends on excess of horsepower divided by weight, and no mechanism can alter the climb from this figure, but it may be obtained at low forward speed; hence the angle of the climb path may be much steeper for the same effective excess of horsepower per unit weight than for an airplane. The flying-speed range also depends on the excess of power available, as greater power is required for horizontal flight both at very small and very great disk incidence; but the autogyro has *no* stalling speed, and as the top speed increases the slow speed *decreases* with increasing margin of power. there will possibly be practical limits with extreme excess of power at both ends of the range.

The vertical nose dive is the same in principle as flying at high power with no disk incidence. Both cases seem beyond the range of what the autogyro will be called on to do with any reasonable power margin.

In reply to Mr. Handley Page, the author said that the torsion of the blade was a serious problem until a section was adopted (Göttingen 429) with fixed c.p. in the usual range of whirling incidence.

Mr. Hodgson's suggestion that rigid blades have advantages and would be required for large machines is entirely contrary to experience. The larger the blades the more necessary it is that the stress should be as nearly as possible pure tension. Mr. Hodgson's test indicating several possible speeds is extremely interesting from the point of view of pure aerodynamical science, but it does not concern the performance of the autogyro, which maintains its own speed at small blade incidence under all conditions from 0 deg. to 90 deg. of disk incidence, once it acquires sufficient angular speed.

Professor Bairstow's argument that the greater length of the blade path means greater drag loss for the same length of voyage must be modified by two circumstances: first, the blades are at a better incidence for L/D; secondly, only a very small and clearly designed part of the whole is moving at these high speeds. (Señor de la Cierva in *The Journal of the Royal Aeronautical Society*, vol. 30, no. 181, Jan., 1926, original paper pp. 8–19, illustrated, and discussion pp. 19–29, *dA*)

ENGINEERING MATERIALS

Pure Beryllium

STOCK, Praetorius, and Pries have obtained pure beryllium in the form of thoroughly fused lumps by electrolysis of beryllium-barium-fluoride in a graphite crucible acting as an anode, with the operation carried out at a temperature of about 1350 deg. cent. (2462 deg. fahr.) The success of the process as compared with previous attempts to do the same thing at a lower temperature is due to the fact that since beryllium melts at 1280 deg. cent. (2336 deg. fahr.) it was necessary to carry it so that it would separate in the course of electrolysis in molten state. It is the first time that such a high temperature has been used for producing metals electrolytically. There was a good deal of difficulty in finding a suitable electrolyte, as this had to be such that it would not evaporate excessively at the high temperature used. The beryllium obtained in this way is hard and quite spongy. (From *Berichte der Deutschen Chemischen Gesellschaft*, vol. 58, 1925, p. 1571. Abstracted through *Zeitschrift für Metallkunde*, vol. 17, no. 12, Dec., 1925, p. 408, *d*)

FOUNDRY

DeLavaud Centrifugally Cast Pipe

EXTRACT from a paper read before the Scottish section of the Institute of British Foundrymen under the title, The Principles of Centrifugal Casting as Applied to the Manufacture of "Spun" Iron Pipes. It deals with the practice of the Stanton Iron Works in England. From this it would appear that three elements control the production of this pipe: speed of rotation, temperature of the metal, and rate of traverse of the mold (with reference to the spout).

A very interesting feature is brought out by the paper not hitherto mentioned, and that is that a very definite segregation occurs in metal cast centrifugally by the DeLavaud process. To insure freedom from excessive migration of the elements, the metal needs to possess as short a cooling range as possible. The ideal composition is therefore a eutectic melt. The metal used at the Stanton Works is a pig iron giving when remelted a content of 3.5 per cent carbon and 3 per cent silicon.

Migration of Elements. Segregation of elements in "spun" castings has been closely studied by taking successive planings from a section of pipe and subjecting them to analysis. The results are shown in graphical form in Fig. 1.

Silicon. This element is uniformly distributed. Only substances in suspension can be segregated in the centrifugal process; no effect is produced on substances in solution. Silicon is present in the metal in solution, and therefore no migration takes place. The graphs for silicon are horizontal in each case.

Sulphur. Manganese sulphide and iron sulphide are not soluble in gamma iron. They possess a low specific gravity and the former has a high melting point. It is easy to realize that these compounds tend to accumulate on the inside of a centrifugal casting. The graphs show clearly the marked inward migration of sulphur.

It is remembered that no migration occurs in the extreme outer

skin of the casting, owing to the quenching effect which it has undergone. With such high rates of cooling the outer layer of metal becomes solid so quickly that there is no time for any segregation to occur.

Manganese. Such manganese as exists as sulphide migrates inward, is described under sulphur. The residual manganese, being in solution, spreads itself evenly through the mass.

Phosphorus. The graphs show that this element accumulates toward the outside of the castings. This is explained by the low melting points and high specific gravity of the phosphide eutectic. This eutectic operated upon by radial force exudes outward through the solidifying mass, and since it does not solidify above 950 deg. cent. it builds up on the outside of the casting just beneath the chilled portion already referred to.

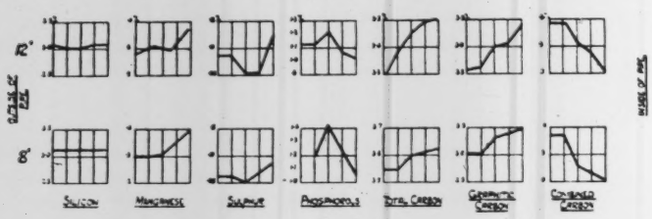


Fig. 1 Segregation in DeLavaud Centrifugally Cast Pipe

Graphite. Carbon as graphite existing in the metal during the early stages of solidification migrates inward on account of its low density. This is to be expected, as the chilling effect of the mold causes a rapid rate of cooling in this part of the casting. The rate of cooling is much less rapid as the inside of the casting is approached, and for this reason the combined carbon percentage becomes considerably less. (First of a series of particles by E. J. Fox and P. H. Wilson, Stanton Iron Works, in *Foundry Trade Journal*, vol. 33, no. 491, Jan. 14, 1926, pp. 23–26, 12 figs., *dc*)

FUELS AND FIRING

Atomized Coal

Data on the use of this fuel for non-ferrous melting. The "atomized-coal system" is the name applied to the use of specially prepared bituminous coal for melting non-ferrous metals, the coal being treated to reduce it to an impalpable powder resembling flour in texture.

Atomized coal differs from powdered coal in its fineness. The latter is standardized to have 75 per cent pass a screen of 200 openings to the lineal inch and all of it pass a screen of 800 openings to the lineal inch, while atomized coal must all pass through a 200-mesh screen and contain grains of further diminishing sizes to the infinitely small. The difference does not appear great at first sight, but has a very substantial influence on the combustion of the coal. Atomized coal is prepared by a succession of steps from nut and slack bituminous coal. It is first passed through a crusher reducing the whole volume to a size not exceeding that of wheat grains, and is then carried through a drier. It is an essential part of the process that the coal must be rendered bone dry so far as it is commercially practicable. From the drier it goes to an atomizer, which is a tumbling-rod mill into which the coal is fed by a screw conveyor through the axle of the mill, in which the coal is kept in agitation by an air blast. The drier has the function not only of removing the moisture but of dissipating the methane gas held between the coal layers. The dissipation of the methane is necessary to render the final product non-explosive within practical commercial limits. The coal is finally collected into strong paper sacks for convenient handling, these sacks ultimately containing a fluffy mass of coal flour which requires special apparatus to feed it into the place of combustion with the proper amount of air.

This is accomplished by a machine called a carburetor, consisting primarily of a storage tank, a revolving disk, and a motor-driven fan. The motor driving the fan, housed in an aluminum shell, also drives the revolving disk at a rate of 18 r.p.m. The disk constitutes the bottom of the storage tank, which is a cylinder of galvanized iron with a capacity of 300 lb. of coal. Mounted on the disk is a cone with projecting arms which at once supports the mass and agitates it to overcome packing or lodging. As the disk revolves, a tangentially placed knife cuts and scrapes off a variable amount of coal controlled by adjusting the angle of the knife. This coal drops off the knife into the fan opening, which blows a mixture of coal-laden air through a pipe into the furnace. In the foundry of the Gibraltar Bronze Co., two furnaces are connected to one carburetor by a "Y" pipe with valves so that either one or both may be operated. In experiments as many as four furnaces have been connected to one carburetor, but it is believed the most satisfactory control can be obtained by not exceeding two furnaces for a carburetor. There is a shutter control for air built in the blower so as the supply of coal is varied the air can be adjusted in compensation. The carburetor was redesigned, and the moving parts consist of the disk, two gears, and a worm drive. It occupies a space 3 ft. in diameter by 5 ft. in height and weighs 350 lb.

The practice that has been heretofore worked out for the air requirements in the combustion of powdered coal of the standard type does not hold good with atomized coal. The air supply and combustion space have been steadily diminished, with a corresponding increase in efficiency and economy of coal. The coal-laden air as mixed and blown into the furnace is under a pressure of three ounces to the inch, or just about sufficient to move the coal, suspended in air, into the furnace. This has the effect of preventing any excess of oxygen, and in conjunction with the restricted combustion space produces a steadily reducing atmosphere, so that losses from oxidation are negligible.

The furnace used is the standard crucible furnace consisting of an iron shell lined with a refractory and covered with a refractory lid with a four-inch orifice directly over the crucible. A collapsible stack is erected over the furnace so that it may be drawn down closely to the lid while firing and elevated to permit withdrawal of the charge. While firing with the stack drawn down the escape for the products of combustion is directly over the crucible, with the result that the non-combustible content of the coal is melted and deposited as slag upon the surface of the charge. This slag acts as an impenetrable seal effectively closing the content of the charge and so limiting losses by oxidation and by the absorption of gases or other impurity. The slag also acts as a flux and assists in the cleansing of the metal. It readily comes off with a skimmer after drawing the crucible. The pipe conveying the coal-laden air enters the furnace tangentially, giving a whirling motion to the flame around the crucible and ascending to the opening over the crucible.

The original article gives data of the cost of melting and the cost of preparation of the fuel.

Atomized coal has not as yet been manufactured upon a commercial scale, so that the proportion of overhead and fixed charges per ton has been relatively high. The cost of material, process, and sacking is about $4.85 per ton. The plant investment for preparation is about $125,000. A charge for capital, interest and depreciation, administration and sales has raised the cost on a small production to $8 per ton, which with freight has made the cost $12 per ton. The fuel comes in stout paper sacks averaging 40 lb. to a sack about the size of a cement sack. It is shipped in box cars to protect it from weather and has a freight classification as a manufactured product much higher than raw coal.

Certain advantages are claimed for this method as used for heating metallurgical furnaces. The installation is not costly, and two crucible furnaces can be equipped for about $1200. The furnace heats quickly and is claimed to produce good metal. The present mill for making atomized coal is located at Evansville, Ind. and operates on an inferior grade of coal, high in ash and sulphur. It is proposed to remove the mill to Cincinnati in order to make available a higher grade of coal. (R. Black and C. L. Schaefer, of the Gibraltar Bronze Co., in a paper before the Syracuse Meeting of the American Foundrymen's Association, 1925. Abstracted through *Brass World*, vol. 21, no. 10, Oct., 1925, pp. 353–354, *d*)

Gyro Pulverized-Fuel Firing

Description of an arrangement (introduced by Lindley, Duffield and Co., Ltd., 199 Piccadilly, London, W. I.) consisting of a pulverizer delivering material to a "gasifier."

The design of the gyro pulverizer is based upon the fact that

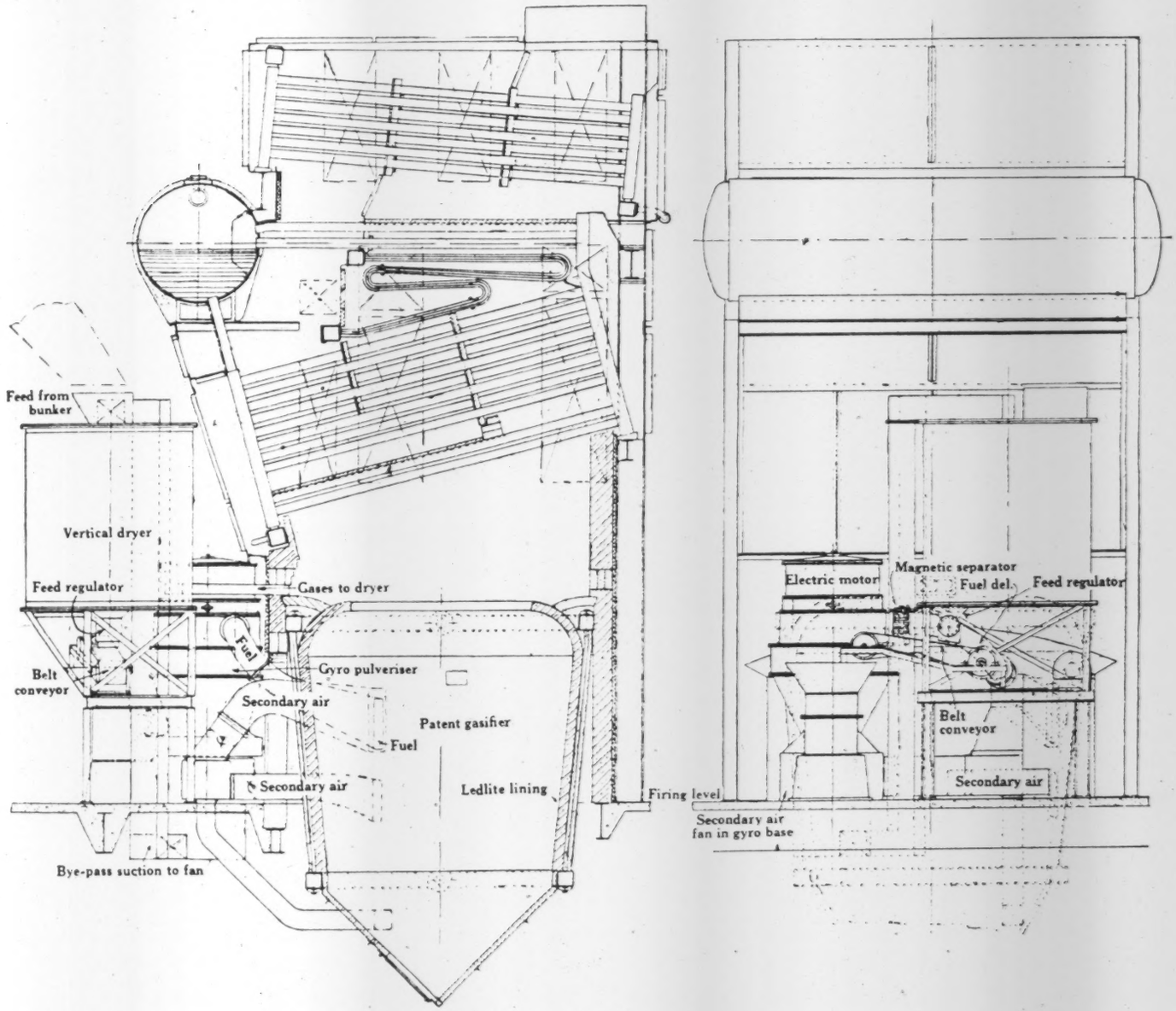


FIG. 2 BABCOCK & WILCOX BOILER EQUIPPED WITH GYRO PULVERIZER

coal has a disposition to fracture readily by impact. The true impact is said to demand relatively little power as compared with crushing or churning. To produce a series of true impacts it is necessary to have a mechanism with ample accommodation for the flying particles of material being pulverized, and to avoid the congestion which churning or crushing entails. In the pulverizer it is therefore necessary to provide a means of rapidly bringing the flying particles of coal back to the zone of impact. The reduced horsepower required results from providing egress for the particles of coal immediately upon their reaching the required fineness, as their continued superfluous presence not only absorbs power but also retards disintegration of the larger particles.

In the gyro pulverizer the coal is subject to rapid impacts against revolving members or beaters on a vertical shaft. The coal by centrifugal force is thrust to the periphery of the conical sides of the pulverizing chamber, and as the desired fineness is reached the finer particles lose their susceptibility to centrifugal force and are borne out of the chamber by the upward draft, which is the controlling factor of their fineness. The fan attached to the top of the pulverizer conveys the pulverized coal at high velocity to the gyro gasifier. The high velocity of injection is a departure from the existing practice of low-velocity injection.

The powdered coal enters the round or oval gasifier tangentially, as indicated in Fig. 2, and again by centrifugal force the coarser particles are sustained in revolution at the periphery of the chamber until such time as they have become gasified. Secondary air is admitted tangentially in the same direction as the powdered coal. The secondary air is divided into two portions, one being admitted near the center of the gasifier and the other at the bottom. The arrangement of the respective proportions of secondary air high up and low down in the gasifier affects the position of the combustion zone. By admitting the preponderance of the air at the bottom of the chamber, greater expansion accrues from the opportunity of preheating, and consequently the passage of the gases through the gasifier assumes a greater velocity, complete combustion ensuing at a greater altitude.

The gasifier deals with the pulverized coal preparatory to complete combustion in the same manner as the bunsen burner deals with gas and air in preparation for its complete combustion at the top of and exterior to the mixing chamber. By this method the brickwork escapes that high temperature which obtains in large combustion chambers. Mixing, ignition, gasification, and complete combustion occur in progressive stages of completeness, and, as before described, the combustion zone being controllable as to locality, the maximum heat can be thus applied to the desired point.

Another characteristic of the gasifier is contained in the exposed surface of a radiant body to the boiler tubes. The gasifier, con-

stituting the radiant body, occupies the full area of the boiler setting, and, unobstructed by combustion arches, has direct radiant application to the tubes. To the extent to which this radiant heat is allowed to be more effectively transmitted, the heat by convection is correspondingly reduced, and higher efficiency results therefrom. In view of the compactness of the gasifying chamber and the small number of refractory bricks required, it is possible to employ a very high-grade aluminous brick, viz., "Leolite," capable of withstanding a temperature of 1850 deg. cent. (3362 deg. fahr.). These bricks are expensive, but the smallness of the chamber justifies the expense by its complete security against breakdown.

The bulk of the ash contained in the coal has a tendency to adhere to the sides of the gasifier in a fluid state. The velocity of revolution of the gases does not admit of this ash projecting; it assumes a thin film over the brickwork, gradually descending until it meets the cold secondary air admitted to the bottom of the gasifier, whereupon it becomes aerated and falls to the bottom as friable honeycomb clinker which, according to analysis, contains 0.03 per cent carbon. The secondary air tends to cool this ash, at the same time itself becoming preheated, thus usefully employing the sensible heat in the ash which otherwise, apart from its loss, might do serious damage in causing the ash to fuse.

An eight-hour test on an 18-year-old 15,000-lb. B. & W. boiler gave the following results:

Washed singles (not fine slack in this instance), wet with free moisture, were dried, pulverized, and burned in one continuous operation in a space no greater than that previously occupied by the chain grate. Perfect control was possible in localizing the zone of combustion, the flame at no point impinging on the tubes. There was no smoke. An efficiency of 80.49 per cent was obtained on this old boiler, with an average hourly evaporation of 20,025 lb. actual. The evaporation worked out at 10.07 lb. of water per lb. of coal from and at 212 deg. fahr. (The guarantee was for $7^1/_2$ to 8 lb. from and at 212 deg. fahr.)

Of the total ash content of 6.7, 4.7 per cent was entrapped and raked out in friable (non-fused) condition. Previous analysis showed 0.03 per cent carbon. The CO_2 content of flue gases averaged 13 per cent throughout the test, while the power absorbed by the motor in pulverizing 2452 lb. of coal per hr. in the pulverizer and blowing it from the gasifier was from 15 to 16 hp. only. The temperature of gases behind the economizer was from 136 to 162 deg. fahr. (The low temperature of these gases is ascribed to the fact that the maximum portion of the heat generated in the gasifier is transmitted as radiant heat, thus reducing the temperature of the convection currents.)

The number of firebricks used in lining the gyro gasifier was only 2500 6-in. bricks, equivalent to 1666 9-in. bricks. American standard combustion chambers for firing the same quantity of coal would require approximately 11,500 9-in. bricks. Gyro gasifier bricks are not called upon to resist the extreme degree of soaking heat conditions that obtains in the larger combustion chambers. (*Iron and Coal Trades Review*, vol. 112, no. 3019, Jan. 8, 1926, pp. 58–59, 2 figs., *d*)

Fuels for High-Compression Engines

THIS report is based very largely on results of tests made at the Bureau of Standards during 1922, 1923, and 1924 under research authorization of the National Advisory Committee for Aeronautics.

From theoretical considerations one would expect an increase in power and thermal efficiency to result from increasing the compression ratio of an internal-combustion engine. In reality it is upon the expansion ratio that the power and thermal efficiency depend, but since in conventional engines this is equal to the compression ratio, it is generally understood that a change in one ratio is accompanied by an equal change in the other. Tests over a wide range of compression ratios (extending to ratios as high as 14:1) have shown that ordinarily an increase in power and thermal efficiency is obtained as expected, provided serious detonation or preignition does not result from the increase in ratio.

There are marked differences between fuels as regards the conditions under which they detonate or preignite. It follows that the employment of a high-compression ratio is contingent upon securing a fuel which is suitable in its resistance to preignition and detonation, and which at the same time possesses the other qualities essential to a satisfactory engine fuel.

This report emphasizes the fact that there may be a difference between a fuel's ability to resist detonation and its ability to resist preignition. Although this report is primarily a general discussion of the properties essential to a satisfactory fuel for high-compression engines, certain fuels, benzol and alcohol in particular, are discussed in some detail. (Standwood W. Sparrow, Mem. A.S.M.E., in Report No. 232, *National Advisory Committee for Aeronautics*, 1925, pp. 3–20, 13 figs., *et.* A bibliography of the subject is given on pp. 19–20)

HYDRAULIC ENGINEERING

Water Turbines of High Specific Speed

A MATHEMATICAL discussion of the factors entering into design and operation of turbines having a high specific speed such as the Kaplan and Bell. By "specific spead" is here meant the angular velocity of rotation of a turbine wheel which would produce 1 hp. under a net head of 1 m. The author uses the following notation: γ is the angle of the blade at the exit side (the author gives an equation which would indicate that this angle must be small); $A = \sigma^2$ where σ is $\frac{r'}{r}$, and r' is the radius of the rotor on the side of the exit of the water filaments, and r the radius on the side of the entrance. α is the angle of entrance of the filaments into the rotor. ϵ is the degree of reaction. The author uses a magnitude which he calls "reduced velocity" and denotes it by $\xi = \frac{w}{\sqrt{2gH}}$ where w is velocity of flow at the entry to the rotor and H is the net head; specific speed may be designated either by ω_s when expressed in radians or by n_s when expressed in revolutions per minute. As far as possible the mathematical reasoning of the author is omitted here because of lack of space, and only the conclusions at which he arrives are reported. One of these is that the angular velocity of a water turbine is proportional to its specific speed, so that turbines which have to develop great power outputs on low heads have a high specific speed and high speed of rotation. In turbines working with a high head, on the other hand, it is necessary to avoid excessively great velocities and work as much as possible with low specific speeds. It is because of this that Pelton wheels operate on specific speeds with an average value of the order of 10, while in low-head turbines the specific speed rises to 500, and in recent wheels operating on extremely low heads the specific speed has been brought to as high as 1000. These figures are in radians.

The author discusses next the influence of the degree of reaction ϵ on the efficiency curve and arrives at the conclusion that in a turbine of the centrifugal type, ϵ and α may be given relatively small values, while in turbines of the centripetal type (radial or mixed) these two factors may be given relatively large values. The author gives an analytical expression for the reduced critical velocity ξ_c and comes to the conclusion that, all other things being equal, an increase of the degree of reaction ξ favors an increase in ξ_c and hence in ξ_m, this latter being the value of the reduced ξ most favorable from the point of view of operation which means corresponding to the maximum value of ρ_i (internal efficiency).

It follows from this that turbines working on low heads should operate with a high degree of reaction and should be of the centripetal type. Moreover, it would appear that the centripetal mixed type is the one to realize the best conditions of exit for the water filaments. In this type of turbine the values of α and ϵ are the same for all the filaments but this does not hold good for the values of σ and γ.

The next subject which the author takes up is the consideration of the general conditions leading to the maximum value of ω_s (specific speed of a turbine in radians). To achieve this it is necessary that N be as large as possible so that the ratio $\frac{a}{r}$ be also as large as possible. From this point of view the centripetal or mixed arrangement has an advantage over the axial, because in this latter the development of a in the direction of the radius is very limited. (a and r are respectively the width and radius of the

rim at the entrance.) It is true that when the head is low it is not possible to increase indefinitely the height of the rim, still the possibilities of increasing the ratio $\frac{a}{r}$ are greater in the mixed type. It is necessary to have sin α and hence angle α large, and the author states that there is another reason why the angle α should be made as large as possible. It is also necessary to make ρ_i (total efficiency) and hence ρ_i as large as possible, this condition being exactly compatible with the economic operation of the machinery. ξ must be made as large as possible, this being due to the fact that ξ appears in the equation for internal efficiency ρ_e in the second power. It would also appear that the degree of reaction must be as small as possible. On the other hand, however, the author claims that the efficiency curve should be elongated as much as possible, which is contradictory to the preceding requirements, the efficiency curve elongating as the degree of reaction increases and not as it decreases. Because of this and because of the fact that it is very important to increase as much as possible ξ_m, it is suggested that the values of the degree of reaction to be adopted be of the order of 0.6 to 0.7.

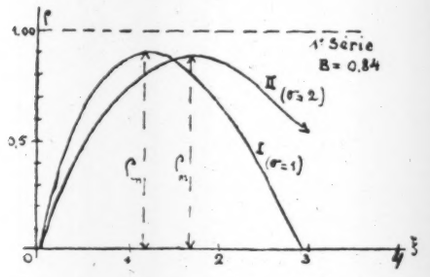
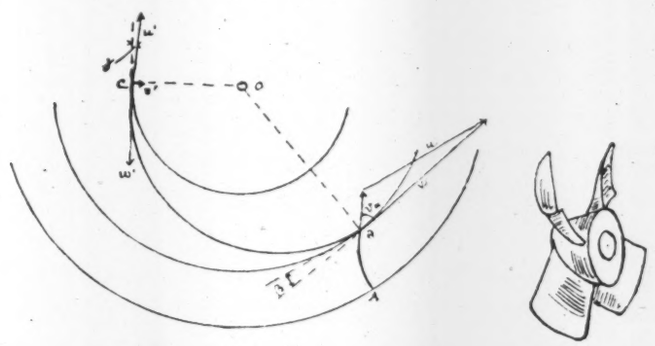


FIG. 3 EFFICIENCY CURVES OF TWO HIGH-SPECIFIC-SPEED WATER TURBINES



FIGS. 4 AND 5 VELOCITY TRIANGLE AND BLADING OF A CENTRIPETAL RADIAL WATER TURBINE

The author then proceeds to a consideration of the factors necessary to give the best, i.e., most elongated, shape to the internal-efficiency curve ρ_i. What he means by "elongated curve" is shown in Fig. 3, where curve II is more elongated than curve I.

From a consideration of his equations and curves he arrives at the conclusion that it is possible to obtain a total efficiency of 0.80 to 0.82 with values of ξ_m of the order of 3 to 6, but to do this it is necessary to put up with a small loss of efficiency. The author ascribes great importance to this interrelation between the values of ξ and the value of the efficiency, and claims that the great difficulties encountered in practice were due to the necessity of reconciling these two conditions, namely, high values of ξ_m and ρ_i. The result is that it is necessary not only to study very closely the structural elements of the wheel, but also to eliminate all the causes of secondary losses. Because of this it becomes necessary to cut down losses due to internal friction in the wheel, etc. On the whole, the increase of ξ_m apparently depends particularly on the reduction of α and B ($B = 2 \cos \alpha \sqrt{1 - \epsilon}$). B is determined here by the values of α and ϵ. If $\epsilon = 0.84$ and $\sigma = \frac{1}{4}$, it will appear that ρ is a maximum for a value of ξ in the neighborhood of 5. The author, however, calls attention to the fact that an increase in the degree of reaction ϵ makes it necessary to employ large sections at the entrance to the wheel. This is only proper in the case of wheels having a high specific speed, as these wheels are large. For example, the Bell wheel has a diameter of 1.60 m. (63 in.) to develop a power of 300 hp. with a head of 3 m. (9.84 ft.). The author considers next expressions for specific speed, in particular in the case of the centripetal radial turbine shown in Fig. 4. Its characteristics are said to be a high value of ϵ and high value of ξ, which means a low value of v with respect to w. The triangle of velocities at the entrance is a very acute one, and the angle β which is made by the blade at the entrance is very small; the angle γ at the exit is likewise very small. We are dealing here, therefore, with extremely developed blades, which means that the number of blades must be small (Fig. 5). As a matter of fact, were the blades placed very close together they would interfere with the free entry of the water. On the other hand, by elongating the blades, frictions are increased. This harmful effect has to be compensated by a reduction in the number of blades.

The author considers next the governing of turbines having a high specific speed. (Ch. DeKeyser, in *Bulletin Technique de l'Association des Ingènieurs sortis de l'Ecole Polytechnique de Bruxelles*, vol. 20, nos. 5–6, 1924, pp. 167–182, *mtA*)

High-Speed Turbines for the Berne Hydroelectric Power Station

AS AT PRESENT operated, the turbines are being run below their best speed, since the periodicity now standard in the district is 40 cycles per sec. This, however, is to be raised to 50 cycles in the near future, and at this speed each of the three new turbines in the new station will generate 630 kw. In the following table a high instructive comparison is made between the old and the new units:

	Old Jonval turbines	New high-speed turbines
Maximum output under three meters head, hp.	130	320
Revolutions per minute	28	214
Specific speed, r.p.m.	95	970
Aggregate electrical output, kw	210	630
Efficiency of turbines	75%	85%
Overall efficiency (water to electrical energy)	57%	81%

The most noteworthy point in the above table is the very large increase which has been made in the specific speed. It also shows that this large increase was accompanied by an increase in the efficiency.

The original article gives an interesting description of the design of the draft tube and compares the new design with that used for the old Jonval turbines in the same station. Among other things, it is stated that in the spiral chamber from which the guide blades are fed the effective roof is formed by a cast-iron plate. This arrangement was adopted because it was desired to use with as little modification as possible the conduits already formed in the concrete from which the original turbines took their supply. By means of the cast-iron plate the effective area of the waterway feeding the new turbines was adjusted so that the speed of the water as it enters the guide blades is constant around the whole periphery.

As shown in Fig. 6, the runner is of the screw-propeller type, but of a somewhat unusual form. It has but two blades and it is slightly greater in diameter at its discharge end than at the inlet end. It is provided, as shown, with a streamline, so as to obviate any possibility of a dead-water space forming below it. The main bearing is of white metal lubricated with oil and water, sealed to prevent air from being drawn in through the turbine. The water used for this purpose is filtered through a sieve, which surrounds the shaft, to free it from the sand carried by the River Aare. The whole of the weight is suspended from a thrust block of the Michell type mounted above the generator.

Comprehensive tests of the second of these turbines were made last February under the direction of Mr. Bitterli, director of the Rhemfelden electricity works, and of Mr. Renggli, who acted for the Control Bureau of the Swiss Institution of Electrical Engineers. The tests were made at two different speeds corresponding, respectively, to periodicities of 40 to 50 cycles in the current generated. Each test was made with four gate openings, and the results are plotted in Fig. 7.

In this figure, the efficiencies have been plotted against the specific speeds corresponding to the four gate openings. It will be seen from the curve that at a specific speed of 700 the efficiency was over 91 per cent, a result which the makers claim has not previously

been obtained with so high a value of N_s. At a specific speed of 600, the efficiency is 90.8, and it is still 86 per cent with a specific speed of 1000. The lower curve plotted in the figure embodies the results obtained with the model turbine and draft tube experimented with at the builders' testing station. This model has a diameter of 50 cm. (19.68 in.), while the full-sized wheel at

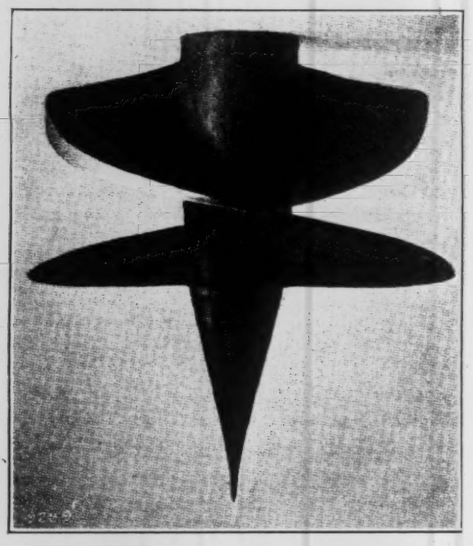


FIG. 6 RUNNER OF THE NEW HIGH-SPEED TURBINE FOR THE BERNE HYDROELECTRIC POWER STATION

Matte had a diameter of 1700 mm. (66.92 in.). The scale ratio is therefore 3.4, and the efficiency attained was some 3 per cent higher with the full-sized wheel than with the model. The builders consider that further improvement would result from still greater dimensions, and that a wheel 3.5 to 4 m. (173.8 to 157.48 in.) in diameter would have a maximum efficiency of 92 to 93 per cent. They attribute the excellence of the results recorded to the fact that the runner has but two vanes, and they also attach importance to the increased diameter of the runner at its discharge end. The runner is the result of very extensive experiments, and its special features have been patented by its constructors. Its design is due to Mr. J. Schnyder, the chief engineer of the turbine department. (*Engineering*, vol. 121, no. 3133, Jan. 15, 1926, pp. 74–76, 10 figs., *d*)

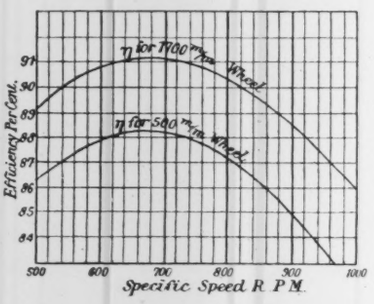


FIG. 7 DATA OF TESTS OF ONE OF THE TURBINES EQUIPPED WITH THE RUNNER SHOWN IN FIG. 6

INTERNAL-COMBUSTION ENGINEERING (See also Aeronautics: The Super Rhone Engine; Fuels and Firing: Fuels for Higher-Compression Engines; Marine Engineering: Plans for First U. S. Shipping Board Motorships; Motor-Car Engineering: Higher Compression Ratio in 1925 Engines)

The Blackburne Thrush Light-Plane Engine

DESCRIPTION of the three-cylinder radial engine of 1500-cc. capacity which recently passed the British Air Ministry's 100-hr. type tests. Its weight is 132 lb. including sump, and it is supposed to develop 35 b.hp. at 2500 r.p.m. and better than 38 b.hp. at 2750 r.p.m. Its fuel consumption averages 0.54 to 0.52 pint per hp-hr.

It is a three-cylinder radial air-cooled engine with overhead valves and a large oil sump built on a separate unit below the crankcase. The hollow crankshaft is built up in two halves, a crankpin being splined at its rear end where it fits into the rear web, slotted so as to enable the pin to be locked in place.

The steel cylinders have detachable cast-iron heads with vertical fins running in a fore-and-aft direction. These cylinder heads are of very symmetrical form and are expected to give the combustion chamber a good shape. (*Flight*, vol. 18, no. 1/889, Jan. 7, 1926, pp. 3–6, illustrated, *d*)

Inlet Stroke Pressures

TESTS made at the University of Illinois show that the absolute pressure at the beginning of the compression stroke varies from 6.5 lb. per sq. in. abs. on low throttle to 1.39 lb. at low speed on nearly full throttle. The tests were carried out on a standard Ford engine and the pressure determinations in the cylinder were made by means of a blast diaphragm Newell indicator. The data are given in the original in the form of a table and curves. The wide range covered by the suction pressures shows the need for a careful consideration of such pressures in any theoretical analysis of engines operating at partial loads where throttling is used to secure these partial loads. (*Automotive Industries*, vol. 63, no. 26, Dec. 24, 1925, pp. 1053–1054, 3 figs., *e*)

Conversion of Reciprocating-Steam Engines to Combined Steam and Internal-Combustion Engines

THE conversion as proposed starts with a modern triple-expansion steam engine 27 in. × 45 in. × 74 in., 48 in. stroke, taking steam from three Scotch boilers which furnish it at a pressure of 180 lb. per sq. in. The engine develops in service 1975 i.hp. at 72 to 80 r.p.m. It is proposed to attach an internal-combustion engine of two-cycle type with port scavenging and exhaust, and airless injection of fuel, the engine being designed to work with a compression pressure of 280 lb. per sq. in. As the diameter of the oil cylinders in this case would be determined by the diameter of the original engine's crankshaft, the oil engine will have three cylinders 25 in. in diameter and 48 in. stroke.

Steam is only admitted to the steam piston during the upstroke, or in other words, the steam engine is made single-acting. The power of the original steam engine is therefore decreased to practically one-half of the original power developed under steam for the same cut-off. On the other hand, the author shows that a very comfortable variation in power can be obtained by the manipulation of the throttle valve and the cut-off in the high-pressure cylinder. Furthermore, the original bypasses are left intact, so that in starting and maneuvering the engine, additional power can be easily obtained by opening the bypasses for the same side of the engine.

The cooling water for the oil cylinders (the latter are designed to run at a somewhat higher temperature than is the ordinary practice) enters the water jackets at the lowest point and leaves the engine through the head. It is pumped directly from the hotwell on the condenser through a filter into the engine, and passes from the engine through the feed heater into the boiler. The water entering the jackets is of a temperature of about 90 deg. fahr. and the amount is calculated so that it leaves the engine at a temperature of 175 deg. fahr.

The exhaust from the oil engines will be carried out through the stack, and the exhaust pipe or manifold in the immediate vicinity of the engine is built with an air receiver around it, through which the scavenging air is passed for the purpose of absorbing some of the waste heat in the combustion gases. Further on in the same exhaust line is fitted a feedwater heater, through which the outgoing circulating water from the oil-cylinder water jackets is passed for the purpose of absorbing more heat from the exhaust gases before the same are finally exhausted through the stack. Through this arrangement the greatest possible amount of waste heat is turned into useful work, which improves the overall economy of the engine.

The engine as designed and proposed can run under oil power alone and develop from 900 to 1500 i.hp. Under steam alone, the engine will develop up to 1000 i.hp. With both oil and steam power combined, the engine will be able to develop 2500 i.hp. at about 80 r.p.m. Therefore it is evident that the flexibility of the

combined engine compares very favorably with that of the old steam engine.

It is claimed that the combination engine will save 30 to 45 per cent of the fuel consumed for the same output by the original steam machinery, equivalent for 280 running days per year to over $26,000. The full data of costs are not given, but it is said that the cost of the proposed conversion would be very reasonable as compared with the cost of an entirely new Diesel plant. (Wm. G. Cox and G. M. Lagergreen, Pusey & Jones Co., Wilmington, Del., in *Diesel and Oil Engine Journal*, vol. 2, no. 1, Jan., 1926, pp. 13-18, illustrated, *p*)

Two-Stroke Mirrlees, Bickerton, and Day Marine Diesel Engine

DATA of a new engine built by a British concern in coöperation as to design with the Swedish Nobel Diesel Co., which has built many engines of such size during the past years.

The engine is of the four-cylinder type, 22 in. bore × 29½ in. stroke, developing its rated power at 125 r.p.m. with a mean effective pressure of 70.5 lb. per sq. in. The speed of rotation is here limited by the requirements of the propeller, and a similar pattern built for land service runs at 140 r.p.m. and develops 1100 b.hp.

There are three valves in the cylinder cover, but only one, the fuel valve, is operative in the normal running of the engine, the other two being brought into action only in starting up or in maneuvering the engine. One of these valves serves for the admission of the compressed air used in starting up the engine. The other also comes into play then, its purpose being to pass this air into the scavenger receiver when the piston makes its return stroke. Owing to this arrangement the scavenging receiver is very rapidly charged, and accordingly the engine can generally be started up on its own fuel after but two revolutions.

The camshaft by which the valves are driven is made in two interchangeable parts. There are in all four control levers, of which two are starting levers, one for each half of the engine; a third is the reversing lever, and the fourth is the fuel-regulating lever. The whole set are interlocked so that it is impossible for them to occupy conflicting positions.

In starting the engine, the motion of the starting lever in the first place opens a valve on the starting air receiver, thus admitting high-pressure air to the starting valves. In the second place, it lowers the levers of these valves and also those of the release valves on their cams. This results in air's being admitted to one or other of the cylinders, forcing down the piston and putting the crankshaft into rotation. Owing to the special provision made for charging the scavenging air receiver, the engine can be got under way very quickly, and in fact the operation of reversing it from full speed ahead to full speed astern takes only 12 sec.

The reversing lever shifts the cams along the camshaft, thus making the necessary alteration in the timing of the valves. The fuel-regulating lever governs the supply of oil to the fuel valves, and thus controls the engine speed. Great flexibility in this regard has been attained, and the engine can be run at the full-load torque at as little as 24 r.p.m., and still lower under sea conditions where the torque diminishes rapidly with the speed.

The scavenger pump is double-acting. Its special feature is its suction valve, which is of the rotary type and is driven from the engine crankshaft by means of spiral gearing as is best shown in Fig. 8. The coupling between the gear and the valve spindle is flexible so as to provide for any small defect from perfect alignment. The gears are lubricated automatically, and the valve spindle runs on ball bearings. The pressure maintained in the scavenging air receiver is only some 2½ to 3½ lb. per sq. in. (gage). This is found to be ample owing to the very large air way provided by the four-seat valve by which the scavenging air enters the cylinder.

As regards the fuel pump, there is a separate one for each cylinder, but all the four are housed in a single casting and are driven by a vertical shaft geared to the crankshaft, which also drives the governor and the camshaft. The plungers are of steel and are lapped and ground individually into their corresponding sleeves. They are quite tight under full pressure, but are yet so free that they can be rotated by the fingers. They are guided solely by their sleeves being loose fits in their cross-bars.

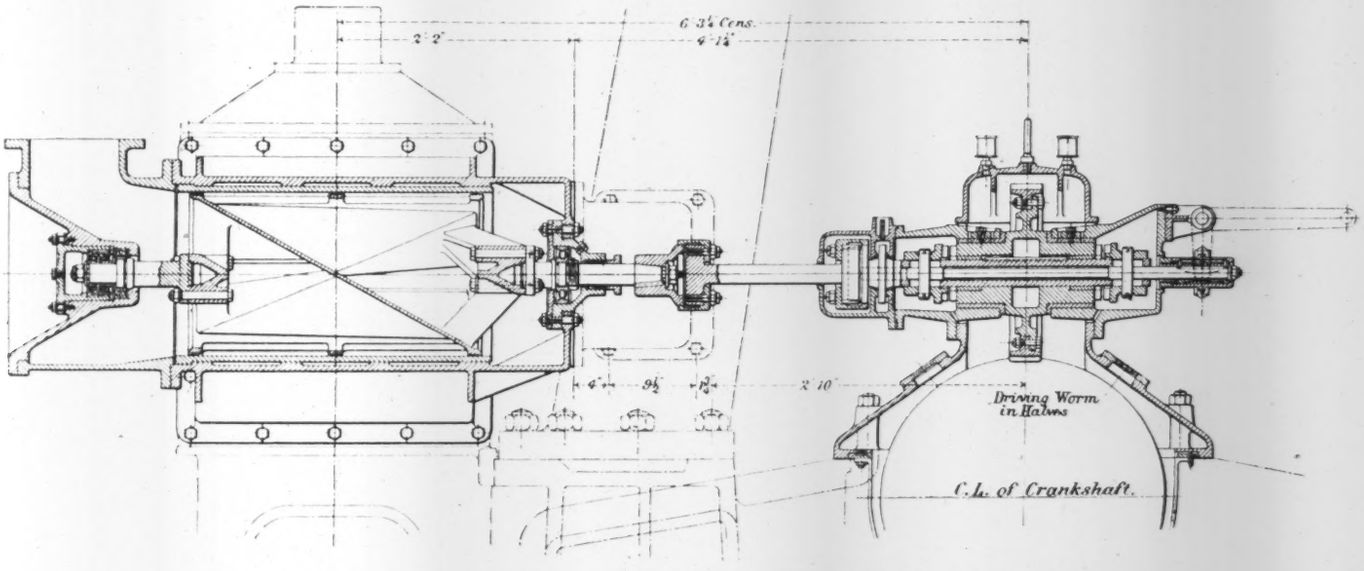


FIG. 8 SCAVENGER PUMP OF THE MIRRLEES, BICKERTON AND DAY 1000-HP. MARINE DIESEL ENGINE

Attention has been paid to the matter of facilitating the inspection of the engine. The pistons can be removed in from 1½ to 2 hr. The crankshaft is in interchangeable halves, and either half can be removed without dismantling the cylinders or the columns. Each half is a solid forging 13¼ in. in diameter at the pins and in the journals. (*Engineering*, vol. 121, no. 3133, Jan. 15, 1926, pp 63-64 and a sheet of illustrations, *d*)

MACHINE TOOLS

A Large Roll-Grinding Machine

THE roll-grinding machine being installed in the Munhall, Pa., plant of the Carnegie Steel Co. has capacity for work 65 in. in diameter and 21 ft. long, which makes it one of the largest grinding machines ever built. (A machine of the same type for rolls 78 in. in diameter and 28 ft. long was constructed by the Norton Company in 1918.) The outstanding features of this machine are forced lubrication, push-button control, and the application of a reversing motor for the table drive. Altogether four motors having a combined rating of 70.5 hp. are employed to drive the machine.

The headstock fixed on the work bed weighs 10,850 lb., of which 1900 lb. is in the spindle. The spindle is 12 in. in diameter, with a total bearing length in its two boxes of nearly 52 in. A radial truing device having a diamond permits of truing accurately to the

radius desired. By locking its spindle the device is also used for truing the face of the wheel. For convenience when truing a wheel not requiring a radius, a plane-table type of diamond-tool holder is provided. (*The Iron Age*, vol. 116, no. 27, Dec. 31, 1925, p. 1086, 2 figs., *d*)

MARINE ENGINEERING (See also Internal Combustion Engineering: Conversion of Reciprocating-Steam Engines to Combined Steam and Internal-Combustion Engines)

Plans for First U. S. Shipping Board Motorships

THE present article describes the proposed alterations to two of the three ships, *Seminole*, *Unicoi*, and *Tampa*. The work proposed is taking out the steam machinery and effecting some alterations in the ships, including the installation of Diesel engines.

The ships are 416 ft. in overall length, 5950 gross registered tons, of longitudinally framed construction, and of about 9400 tons deadweight capacity.

These two vessels are to have the Worthington type of double-acting two-cycle engines with four cylinders of 28 in. diameter and 40 in. stroke to develop the guaranteed 2900 shaft hp. at 95 r.p.m. The engine weighs about 600,000 lb. with attached compressor and scavenge manifold, flywheel with turning gear, and engine auxiliaries. It measures 31 ft. 7 in. base length and 10 ft. 10 in. base width. There are also three auxiliary sets to be installed, each driving a 75-kw. generator.

Fresh water for cooling will be carried in the inner bottom tanks under the machinery space and a centrifugal pump will draw from either one of these tanks, port or starboard, and discharge through the fresh-water cooling system to the connections on the main engine. The outlet from the cylinder jackets, head, and exhaust manifold will be connected back to both tanks with a bypass connection overboard. The outlet from the pistons will be run to the outlet connection from the jackets with a bypass connection to the engine-room bilge. In the discharge line between the fresh-water cooler and the main engine an electrical alarm with loud gong will be installed for operation in case of failure of the fresh-water cooling system. In the event of such a failure sea water can be supplied to the main engine. The auxiliaries are at all times cooled by sea water. For the salt-water system there will be both a low suction and a high suction, the former for normal sea use and the latter in rivers. (*Motorship*, vol. 11, no. 1, Jan., 1926, pp. 23–26, illustrated, *d*)

METALLURGY

The Flow Method of Pouring Steel Ingots

IT IS claimed that in the ordinary method of pouring ingots there may be a high head pressure on the metal coming out of the ladle nozzle, and that this stream forces itself to a considerable depth into the metal previously poured, which causes slag and impurities which may have come to the surface to be forced down again into the middle of the mold. It is claimed that the same thing happens with gas bubbles.

To avoid this a reservoir is provided with a float. The reservoir appears to be merely a short clay tube sitting in the top of the ingot and supporting the float, which latter is a clay vessel with holes properly distributed in its bottom.

The metal comes from the nozzle of the ladle into the float, and apparently its velocity is broken up while it is spreading in the float so that it comes through the float holes with a reduced velocity. Where the closed type mold is used the reservoir supporting the float may be eliminated. It is claimed that better steel is produced by this method and that the stripping of the ingots is made easier. (John D. Knox in *Iron Trade Review*, vol. 78, no. 2, Jan. 14, 1926, pp. 139–142, 10 figs., *d*)

MOTOR-CAR ENGINEERING

Higher Compression Ratio in 1925 Engines

THERE has been a gradual increase in compression ratios as compared with the past in motor-car engines brought out in 1925. This is probably favored by the decrease in the cylinder volume and by a better understanding of the laws of heat flow in combustion chamber walls which has permitted the reduction of the excess temperature of hot spots. Possibly improvement in fuels also has been a contributing cause. Aluminum-alloy pistons may also have helped toward making the higher compression possible. As a matter of fact, highest compressions are usually carried in engines with alloy pistons.

The remainder of the article discusses other changes in the design of the engine and accessories. (P. M. Heldt. *Automotive Industries*, vol. 54, no. 2, Jan. 14, 1926, pp. 50–54, illustrated, *g*)

POWER-PLANT ENGINEERING

A Steam Turbine Plant

IN A steam-turbine installation with multi-stage preheating of the feedwater and at least one auxiliary turbine driven by tapped or bleeder steam and connected to the feedwater heater, the auxiliary turbine in addition to being supplied with bleeder steam is connected to a source of steam of approximately constant pressure, so that under all conditions of working it furnishes a certain minimum power. Thus, a steam boiler I supplies the main turbines 3, 4 and also a section 13 of the auxiliary turbine, which has another section 14 receiving bleeder steam from the main turbine by way of pipes 19, 21. The steam of the section 13 passes into the highest stage 11 of the feedwater preheater, the next stage 10 being heated by bleeder steam from the pipes 19, 22, and the lowest stage 9 by steam from the section 14. Instead of dividing the auxiliary turbine into two-sections 13, 14, it may be provided with two groups of nozzles for the two steam sources. The sections 13, 14 may be housed in two casings, which may be coaxial, or the two sections may be geared together. A separate steam boiler may be used for the auxiliary turbine, and this boiler may be heated by steam from the main boiler. The stage 10 may be omitted. (British Patent No. 242,210 to W. Anderhub, *The Illustrated Official Journal (Patents)*, no. 1927, Dec. 23, 1925, p. 5889, *d*)

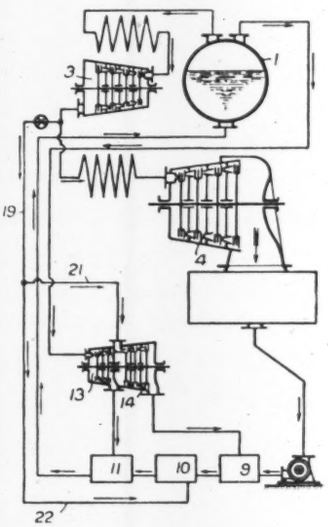


FIG. 9 MOTOR POWER PLANT

PUMPS

The Bates Pump

THE Bates pump is actuated by a dry vacuum pump, the function of which is to maintain a vacuum of about 20 to 25 in. of mercury. It is shown in Fig. 9, where *A* is the suction pipe with *B* the non-return valves; *C*, the S-shaped inlet pipe; *D*, one of two similar pump bodies; and *K*, the water outlet.

The dry air pump exhausts air from one of the pump bodies with which it is in connection for the time being, through an outlet-valve gear and float valve, both of which are open. The water-outlet flap valve is closed. The vacuum is created in that chamber, the S-shaped pipe, and the suction pipe, and water rises in the suction pipe for a distance corresponding to the vacuum obtained. The air-"gulp" regulating valve then admits a gulp of air at atmospheric pressure into the suction pipe. The air rising and expanding in it as it rises carries with it a body of water up the suction pipe to the pump body in which water collects while the air is drawn away by the direct vacuum pump. Successive gulps of air being automatically delivered continue to drive more water into the pump, which therefore eventually becomes filled with water.

When so filled the float belonging to the vacuum-breaking valve rises and brings a rubber valve against a seat, where it is firmly

held by suction from the dry air pump. The result of this is that the pump body is no longer in communication with the air pump. At the same time the float opens a valve which admits air at atmospheric pressure to the pump body, with the result that the water-outlet flap valve, which was previously held in its place by outside atmospheric pressure acting against the internal vacuum which now no longer exists, falls open due to the weight of water above it and the contents of the pump body are discharged by gravity.

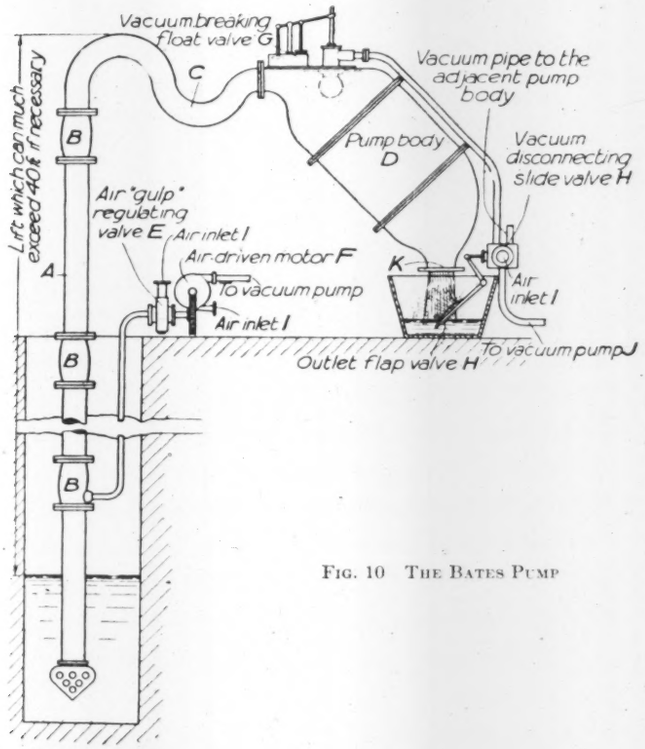


FIG. 10 THE BATES PUMP

In falling open the vacuum pump is simultaneously disconnected and the length of vacuum pipe between this point and the vacuum-breaking (float) valve is opened to atmosphere, with the result that the rubber valve previously held by suction against its seat falls open by gravity, and remains open until the float again brings it into action during the next cycle.

Now as to the other pump body. Its water-outlet valve was closed by the movement of the discharging outlet valve and at the same time this pump body was connected to the vacuum, so that the water-outlet valve sits immovably fast due to the vacuum on the inside and atmospheric pressure on the outside.

Eventually this pump body becomes filled with water in the manner already described, and in a similar manner discharges its contents and so sets the first-mentioned pump body into function.

Thus the two pump bodies are alternately automatically filled and emptied. (*The Machinery Market*, no. 1313, Jan. 1, 1926, p. 26, 1 fig., *d*)

A Rotary Liquid Pump

DESCRIPTION of a rotary pump of the American Machine and Foundry Company, Brooklyn, N. Y. The rotor is a plain drum like the armature of a motor. Upon the surface of this drum is cut a wide or shallow helical groove, across which lies a dam or vane. This vane is short, light, and rectangular in shape, and may be made of metal or lignum vitae. The vane reciprocates positively under the cam action of the helical groove in the drum. The drum rotates but the vane is restricted from rotating by the fact that it is assembled through a slot in a diaphragm which is either a part of or rigidly connected to the pump housing. (Fig. 11.) Mounted eccentrically in the drum housing and on the drum shaft, the drum is thus naturally balanced both statically and dynamically. The pump shaft is packed with an improved form of stuffing box at the inboard end, and an oilless blind bearing is used on the outboard end for small fractional-horsepower pumps. On larger pumps both ends of the shaft are packed. The shaft bearing is of the ring-oiler type with a packing gland. The gland can be removed and new packing inserted without disturbing the bearing.

Ports of the pump are symmetrically spaced with respect to the vane, and the pump may consequently be well operated in either direction of rotation with no physical change. The vane engages in the cam groove at the upper element of the main drum, and in the larger sizes is accessible through a handhole plate.

The efficiencies for a $2^1/_2$-in. 83-gal.-per-min. rotary pump are given in the original article. (Francis Juraschek, American Machine and Foundry Co., Brooklyn, N. Y., in *Marine Review*, vol. 56, no. 1, Jan., 1926, pp. 29, 60, and 64, 5 figs., *d*)

RAILROAD ENGINEERING

Looking Ahead in Respect to Railroads

IN POINTING out the increase of efficiency of modern railroads the author cites a case when he was traveling with a railroad executive on one of the southeastern roads and found that officers from one end of the railroad to the other were asking their subordinates in the operating department, "What is the oldest car in the yard," meaning thereby the car held longest. He expresses the opinion that if this question were asked in the same way at all the division points and yards in this country and not on one or two railroads only, it would largely effect the speeding up of the movement of freight cars. Regarding the future, he considers as the greatest problem of the railroads, and one which will have a larger effect upon improved operation than many other factors, that of providing better-trained men and a higher type of leadership. Too little attention has been given to the recruiting of forces on the railroads, to seeing that men who entered the service are fitted for the tasks to which they are assigned, to coaching them after they enter the service, and then to seeing that they are given the right sort of training and the opportunity to fit themselves for promotion.

In telling of a younger railroad men's conference recently held in Pittsburgh, the author elaborates upon the value of such activities and points out the great importance of instilling in all railroad officers, supervisors, and workers the recognition of the dignity of railroad employment.

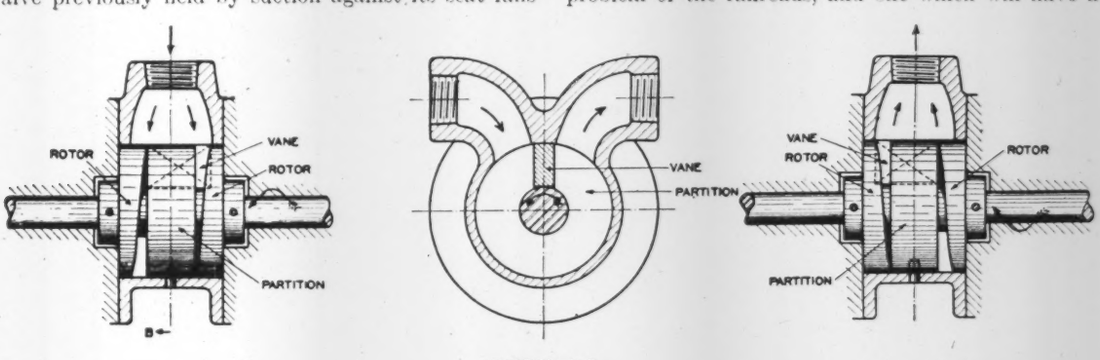


FIG. 11 DIAGRAMMATIC VIEWS OF THE NEW $2^1/_2$-INCH, 83-GALLON-PER-MINUTE ROTARY PUMP OF THE AMERICAN MACHINE AND FOUNDRY CO.

The question of leadership is of practical interest. Industry has been slowly awakening during the past few years to the fact that there is much useless friction and lost motion because the supervisory staff, from the top of the organization down to the foremen who come in intimate contact with the men, has not had adequate training in the art of leadership or the principles of successful foremanship. Men have been promoted to supervisory positions because they were good workmen. Several years were required to prepare themselves as skilled workers, whether in the shop or in the office, and then they have been placed in charge of men without having any special coaching or training as to how to lead men. Yet it is coming to be recognized that industrial leadership is just as much of a science as medicine or any other profession. Somehow or other the railroads must see to it that the supervisory staff gets the information and training which will help them to grasp the fundamental principles of successful management. Many railroad officers and foremen have been awakening to this situation. This fall, for instance, has witnessed quite a general movement among the railroads throughout the country in setting up of foremen's clubs or classes, or of providing other means of training the supervisors in the art of leadership. (Roy V. Wright, Mem. A.S.M.E., in Official Proceedings of *Railway Club of Pittsburgh*, vol. 26, no. 1, Nov. 27, 1925, paper, pp. 5–24 and discussion, pp. 24–32, *g*)

REFRIGERATION

Improvements in the Design of Refrigerating Compressors

An article dealing exclusively with the work done at the plants of Sulzer Bros. Co. in Winterthur, Switzerland.

The most significant change which occurred in the design of refrigerating compressors within the last years is the increase in speed, and the original article shows, for example, a compressor direct-coupled to a 1200-hp. steam engine and running at 150 r.p.m., the rated capacity being 16,000,000 B.t.u. per hr.

One of the most important factors in the design of these compressors is the question of valves, the valves having been made practically massless. In the old refrigerating machines when a valve broke the pieces fell into the cylinder and, being heavy, caused great damage to the cylinder covers, and sometimes breakage of the frame of the machine. With light disk valves which cannot fall into the cylinder even if they happen to break, such disastrous consequences are eliminated. The disks are comparatively inexpensive and can be quickly and easily replaced.

An important improvement is due to adapting the design of the compressors to dry working; that is to say, an appropriate device is fitted in the pipe lines which insures the gas arriving at the compressor in a dry state, thus sensibly reducing the bad effect of the clearance on the efficiency of the machine. For this reason it is possible to choose the cylinder bore comparatively large with respect to the stroke of the piston, and to increase the number of revolutions without increasing the piston speed; the latter speed is rather below the limits hitherto considered admissible, which is a great advantage in comparison with former designs.

A high-speed compressor can be obtained merely by increasing the speed of a machine designed for a lower speed. The Sulzer Bros. Co. had to go through extensive experimentation before deciding on their new type of compressor. Great changes in the compressor were ultimately produced. In the horizontal ammonia compressors, for example, the old massive bayonet frame with the open or flat one-sided crosshead guide has disappeared; a single crank which was once the rule and allowed of only one main bearing has also gone; the new type of frame—much more rigid although lighter than the old one—is in the form of a fork with a bearing at each extremity on which the double through crankshaft has accurately carried. The entire mechanism of the compressor is therefore guided with certainty and precision.

On the other hand, the outer bearing is no longer considered necessary to insure correct alignment of the shaft when a compressor is directly coupled to an electric motor. The alignment of the shaft is no longer left to the erectors. The old soft packing is replaced by a stuffing box with metallic packing and forced lubrication. To increase the reliability of working of the compressor the safety and bypass valve have been combined. By means of the hand-regulated bypass valve the compressor can be more easily started up, and an automatic safety device fitted in the same housing allows the delivery gases to be returned to the suction side should the pressure exceed a certain limit.

Allusion has already been made above to the advantage of working with dry compression. Under this system the gas is drawn into the compressor in a dry saturated state (i.e. in the state where $x = 1$), while with wet compression the gas enters the cylinder in a moist state, or at least heavily saturated (where x is less than 1). Working with dry compression effects a considerable improvement in the efficiencies as compared with those realized in the old machines using wet compression; the use of such machines is consequently always becoming less and less common. In working with wet compression the temperature scarcely exceeds 85 to 105 deg. fahr., while with dry compression this temperature is very usually as high as 195 to 212 deg. fahr. of even more; the height to which it rises depends on the difference between the evaporating and condensing pressures. In wet working the particles of liquid carried over into the cylinder by the gas adhere to the walls and thus increase the transmission of heat between the walls and the gas. The walls, having absorbed a certain amount of heat during the compression stroke, return this heat, during the suction stroke, to the fresh wet gas being drawn in; this causes a partial evaporation of the liquid particles contained in the gas, thus diminishing the volumetric efficiency of the cylinder. In addition to this, in wet working the clearance spaces necessarily retain some of these liquid particles, and these evaporate on the return stroke, hindering for a certain time the entrance of fresh gas into the cylinder, and thus further reducing the efficiency.

When the compressor draws in only dry gas, the heat exchange between the gas and the cylinder walls is diminished and the adverse effect of the evaporation of liquid particles enclosed in the clearance at the end of the stroke is eliminated. Great importance was at one time attached to getting the clearance reduced to the lowest possible amount, but this is not so necessary when working with dry compression, and the designer of the machine has more freedom in choosing appropriate cylinder ends and the location of the valves.

It has been proved in practice that, when working with the wet process, the compressor must either run at a correspondingly higher speed or have a cylinder of greater bore if it runs at the same speed, in order to obtain the same output as with dry working.

The reduction of the cylinder dimensions, due to the adoption of dry compression, at the same time reduced the friction losses of the piston and consequently increased the mechanical efficiency of the compressor. (*Sulzer Technical Review*, no. 4, 1926, pp. 6–9, 2 figs., *d*)

STEAM ENGINEERING

The Early Days of the Steam Engine

In "A Treatise on the Steam Engine" published by John Scott Russell in 1841 there occurs the following statement: "It is a singular peculiarity in the history of the steam engine that ever since the period which exhibits the earliest traces of its embryo it has continued slowly and gradually to advance with the flow of time toward its present state of high maturity, though not yet perhaps of ultimate perfection."

The article describes several well-known types, such as the Savary, Newcomen, etc. The state of steam engineering in the days just before Watt is illustrated by the fact that except at the mouths of coal pits, steam engines were considered less economical than horses, and even there the only reason why such engines were used was because "the worst sort of engine would raise more coal in 12 minutes than it would consume in 12 hours." (R. C. Rowe in *Canadian Foundryman*, vol. 12, no. 12, Dec., 1925, pp. 22–25, 6 figs., *h*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Engineering and Industrial Standardization

Unification of Wire and Sheet-Metal Gages

THE Society of Automotive Engineers has requested the American Engineering Standards Committee to take up the unification of wire and sheet-metal gage systems in order to arrive at a national standard system of designating the diameters of metal wires and the thicknesses of metal sheets. The systems of gage numbers by which these products are generally designated at present have been developed and adopted in the course of time in different trades and for different products, as steel and copper wire, aluminum, brass and zinc sheets, etc. In the request submitted by the Society of Automotive Engineers there are listed 13 gage systems now in use in this country. For example, the "American wire gage" or "Brown & Sharpe gage," which is widely used for non-ferrous wires (copper, brass, aluminum) was devised in 1856 by the founders of the Brown & Sharpe Manufacturing Co. and adopted by the Association of Brass Manufacturers in 1857. The name "American wire gage" is of a later date. Steel wire, however, is indicated by various systems of gage numbers which not only differ from the "American wire gage" system for copper wire, etc., but also differ from each other.

A conference of all industrial groups interested in this problem will be called in the near future, to discuss the desirability and possibility of unifying the various existing gage systems into a consistent national system, or systems.

A question which is closely connected with that of the designation of wires and metal sheets is whether or not it is feasible to thin out the series of diameters or thicknesses actually listed in the catalogs of the different trades. Inasmuch as a procedure of this nature involves the element of "simplification," the American Engineering Standards Committee and the Division of Simplified Practice of the Department of Commerce have made arrangements to coöperate actively in this matter.

In the meantime, any suggestions with regard to the general technical problem, or any of its phases, will be welcomed by the American Engineering Standards Committee, whose address is 29 West 39th Street, New York City.

Drawing-Room Practice to Be Standardized

THE American Engineering Standards Committee announces the launching of a comprehensive program of standardization of drafting-room practice. This action follows the unanimous recommendations of a representative conference held in December, which was attended by fifty individuals, representing a total of forty-eight professional societies and trade associations, large engineering schools, and manufacturing concerns particularly interested in drawings for shop and construction work.

Doing away with the diversity in drafting-room practice and in the materials, equipment, and tools used for making drawings will result in a more ready understanding of drawings by everybody for whom they are intended, in great savings in the draftsman's time and efforts, and in a more efficient use of drafting materials and filing cabinets for the storage of completed drawings. One of the important items is, for example, the series of sizes for drawings. If these can be standardized, it will not only be possible to utilize drawing paper and tracing cloth as it comes in rolls of sheets to the greatest advantage; but it will also be possible to supply the drafting department with sheets cut to size in advance, and on which the border line and the several spaces for title, the part list, etc., have been printed.

Besides the question of drawing sizes, the program adopted by the conference contains mainly the following items: classification of and corresponding nomenclature for drawings in accordance with their purpose; method of representation of the subject, as, for example, the arrangement of views and sections; indication of dimensions and tolerances; indication of surface or finish; symbols representing in a diagrammatical form certain elements of construction, as threaded parts, gears, etc.; the arrangement of drawings as to border line, title, notes; indication of changes and revisions; method of folding, etc.; the kind and size of lettering, figures, and symbols; scales of reduction or enlargement; sizes of filing cabinets; drafting equipment and tools (triangles, scales, etc.); specifications for materials to be used for drawings (paper, tracing cloth, inks, pencils, etc.).

The work will be carried out by a large sectional committee on which all interested groups will be represented, under the sponsorship of The American Society of Mechanical Engineers and the Society for the Promotion of Engineering Education.

Use of Specifications in Foreign Trade

AT meetings of the American Engineering Standards Main Committee and Executive Committee those specially interested in the various phases of standardization are requested to address these committees. The Executive Committee invited M. H. Bletz, of the Department of Commerce, to introduce the discussion on the use of specifications in foreign trade at its January 14 meeting. Following Mr. Bletz's remarks, which are reproduced below, the members of the Committee discussed the subject at some length and voted that Chairman Skinner appoint a special committee of five members to consider Mr. Bletz's proposals and to report at the next meeting.

Mr. Bletz spoke as follows:

When the Bureau of Foreign and Domestic Commerce was in the course of expansion from a purely statistical organization to one whose objects included the promotion of foreign trade on a rather broad scale, one of the problems, presented by industry, was the translation and publication of editions of certain material specifications in foreign languages. During 1917 to 1919 the Bureau released a Spanish edition of 62 separate specifications for ferrous and non-ferrous products and cement, and also a French edition of 61 similar standards. Since 1920 nothing has been added to either series but during 1925 two specifications in Portuguese (for rails and accessories) were released, and the work of revising the Spanish edition was assumed due to the fact that the English text of 42 numbers had been altered during 1921 to 1924 inclusive.

Originally this work—the preparation, publication, and distribution of 125 specifications—cost about $15,000. They have proved of practical value on many occasions, and there is reason to believe that whatever was spent on this series has been liquidated by profitable transactions.

The object of issuing these editions was to promote a knowledge and use of our specifications abroad, and it was believed this could be better done in the language of the importing country than in that of the country of origin.

The A.E.S.C. has a similar object as stated in Section C-5 of its constitution: i.e., "To promote in foreign countries the knowledge of recognized American engineering standards." I know that the A.E.S.C. is first interested in the promotion and the use of specifications at home and abroad. While it is not your motive to push the use of American specifications abroad exclusive of others, it is only natural that you should favor those originating in the United States until such time as there are international standards.

During the past year we have had repeated requests for copies of these standards published by the Bureau which we have been unable to fill. The Director would like to revise the Spanish edition, but that does not seem possible under our 1925–26 printing allotments. You see, while Congress has allowed funds for the expansion of the Bureau's personnel and activities both at home and abroad, it has not provided printing funds either in proportion to this expansion or in conformity with the advancing cost of publications.

A few words as to what the British and the German organizations are doing along this line would be appropriate at this point. Lately the British Engineering Standards Association has been endeavoring to accumulate funds to revise its French, Spanish, Portuguese, and Italian editions. Mr. Le Maistre stated recently that his association had already spent some £25,000 (about $110,000) in this line of work, and considered it well worth while.

The German Industrial Standards Association since 1922 has published a number of standards in a Spanish edition. This body is doing a splendid job. For example, its booklets on bridge material and on transmission equipment are practically textbooks on the subjects.

Further, as a result of a request to the League of Nations by 12 of the Latin American countries concerning protection of the foreign buyer against receipt of worthless goods, the Economic Committee of the League is making quite a study of the means existing in producing countries to this end and for this purpose. In its preliminary report, among other things, may be

found the recommendation that the foreign buyer avail himself of the use of the recognized specifications adopted in the country of origin.

In consideration of all this I wish to suggest that the A.E.S.C. create a forum to determine if the present is not an opportune time to launch a definite project for the promotion of a greater knowledge and use of recognized United States standards in foreign trade, and particularly in connection with inter-American trade. If the time is favorable, then the A.E.S.C. could assist by organizing a launching committee to determine policies, and follow with the organization of an operating committee to work out the detailed program and supervise its development.

It would certainly be advantageous if a working committee could be organized under A.E.S.C. procedure for the promulgation of American standards in foreign languages, and for the American Manufacturers Export Association, the Chambers of Commerce of the U.S.A., the Export Managers Club, National Foreign Trade Council, and similar bodies interested in foreign trade promotion to act as sponsors of such a committee and movement. I believe a permanent staff could be employed at an annual outlay of $20,000. This might be pared down to a minimum of $15,000. Publication and distribution costs could be kept within an additional $8000 per year with an adequate sale of the printed standards.

On the other hand, the work might be done by a Government agency if sufficient pressure was employed to result in regularly assured funds for the purpose. Surely Government personnel would coöperate in so far as desired and possible.

The most important part of the operating phase of the work will be the selection of standards to be translated. These could include material and design specifications for exported and imported commodities, and certain standard codes and formulas that will stimulate international commerce and understanding. In this respect the German Industrial Standards Association is no doubt profiting from the experience developed by the Bureau's editions and those of the British Engineering Standards Association.

While eventually selection could be made only from standards approved by regular A.E.S.C. procedure, for a period of one or two years, in order to round out the field of endeavor, other nationally recognized standards should be given consideration.

However, the important thing is to determine whether this work should or should not be done at this time. If your committee thinks that the time is ripe for deciding the question, perhaps a special committee could be organized by the A.E.S.C. along rather broad lines and permitted a latitude commensurate with the scope of the problem. It would first decide whether the work should be undertaken, and, if the decision be affirmative, would proceed to organize some definite plan of action.

International Critical Tables Soon to Be Published

THE National Academy of Sciences and the National Research Council will shortly announce the forthcoming publication of International Critical Tables of Numerical Data of Physics, Chemistry, and Technology.

The material contained in International Critical Tables has been collected and critically evaluated by some three hundred coöperating experts, including chemists, physicists, and engineers of the United States, Canada, Great Britain, Belgium, France, Italy, Austria, Germany, Denmark, Switzerland, Holland, Australia, and Japan.

The scope of the material collected covers all available information of value concerning the physical properties and numerical characteristics of (*a*) pure substances, (*b*) mixtures of definite composition, (*c*) the important classes of industrial materials, (*d*) many natural materials and products, and (*e*) selected data for selected bodies or systems, such as the earth and its main physical subdivisions, and the solar and stellar systems. Publications of the world in all languages have been combed for data, and much valuable and hitherto unpublished information has also been collected.

In making the publication contract, the National Research Council has reserved to members of scientific and engineering societies, and to libraries and research laboratories, for a certain period, the right to purchase the volumes at the estimated manufacturing cost.

International Critical Tables will be issued as a set of five volumes comprising an estimated total of 2500 pages $8\frac{1}{2} \times 11$ inches. The subscription price of the Tables up to the appearance of Volume I, early in 1926, will be $35 to members of contributing societies, of which The American Society of Mechanical Engineers is one. After the appearance of Volume I the work will be placed on the market by the publishers at their regular price of $60 for the set of five volumes.

Those desiring to place an advance order for a set of these International Critical Tables at the low prepublication price are advised to communicate directly with the National Research Council, Washington, D. C.

A.S.M.E. Boiler Code Committee Work

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in MECHANICAL ENGINEERING.

Below are given interpretations of the Committee in Cases Nos. 515 to 518, inclusive, as formulated at the meeting of January 8, 1926, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE NO. 515

Inquiry: Will a composition of steel boiler plate having a copper content not exceeding 0.35 per cent, be acceptable for use in boilers built under the requirements of the Power Boiler Code? In other words, is it to be understood that in the absence in the present specifications for steel boiler plate of any requirements or limits for copper, there is no objection to the presence in such steel boiler plate of a copper content up to 0.35 per cent?

Reply: There are no requirements in the Boiler Code specifications for steel boiler plate that pertain to copper content. It is the opinion of the Committee that if the chemical and physical characteristics of such steel comply with the specifications in the Code for steel boiler plate, it may be considered to meet the requirements of the Code.

CASE NO. 516

Inquiry: Will a nozzle mounted on a shell or drum formed of pipe which embraces a neck or liner extruded from the metal in one side of the pipe, over which is fitted a forged or cast-steel nozzle block, having grooves into which the extruded neck is expanded, be permissible under the Code? The space surrounding the top of the liner is acetylene-welded and machined, and also the junction between the bottom of the forged or cast-steel saddle is welded to the pipe, but it is pointed out that the welding is for finish and appearance only and is not required for either strength or tightness. In a test of an 8-in. nozzle of this construction, but without the welding, it required 1000 lb. to produce a slight leak, and when the nozzle was rerolled, it withstood 2000 lb.

Reply: It is the opinion of the Committee that if the nozzle construction referred to has a factor of safety of 5 under test at the working pressure intended, without taking the holding power of the welds into account, and if the other portions of the construction conform fully to the requirements of the Code, the construction described will meet the requirements of the Code. For example, the test reported would indicate that the nozzle is suitable for use at 400 lb. working pressure as the maximum, provided the materials and construction conform to the Code requirements for this pressure.

CASE NO. 517

Inquiry: Is it the intent of Par. P-297 that the term "maximum allowable working pressure" shall apply to the maximum design pressure of a boiler where a boiler designed for a high working pressure is operated at a much lower working pressure? It is found impracticable in operation to work with steam gages graduated to conform to the maximum design pressure, but it is much more convenient in operation to have the steam gage graduated to conform to the pressure at which the safety valves are set to relieve.

Reply: The first part of Par. P-297 refers to "the pressure at

which the boiler will operate," and it is therefore the opinion of the Committee that the term "maximum allowable working pressure of the boiler" was in this instance intended to apply to the maximum pressure at which the safety valves on the boiler are set to relieve.

CASE NO. 518

Inquiry: Is it not permissible in applying the formula in Par. P-199 for braced and stayed surfaces in boilers where the staybolts are not symmetrically spaced, to consider the load carried by each staybolt as the area determined by taking the distance from the center of the spacing on one side of the staybolt to the center of the spacing on the other side? Attention is called to the fact that the term p in the formula specifies the maximum pitch measured between straight lines passing through the center of the staybolts in the different rows, but that the formula is presented with a definite implication that the staybolts are symmetrically spaced.

Reply: In cases where the staybolting of boiler plates is unsymmetrical for reason of interference with butt straps or other construction, it is the opinion of the Committee that in addition to the special provisions of Pars. P-205 to P-207, it is permissible to consider the load carried by each staybolt as the area calculated by taking the distance from the center of the spacing on one side of the bolt to the center of the spacing on the other side.

Correspondence

CONTRIBUTIONS to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on activities or policies of the Society in Research and Standardization.

Standardization of Hydrants and Hose

TO THE EDITOR:

As a sponsor society you will probably be interested in the results obtained in Mississippi in connection with standardization of hydrants and hose. This work was started in the city of Jackson, capital of the state, in June, 1925, and up to January, 1926, the following results had been obtained:

Towns completely standardized	21
Towns found standard by actual test	6
Standardization refused	1
Standardization postponed for act of Board of Aldermen	3
Towns impossible to standardize due to small diameter or 6 thread per inch pitch	11

In one of the last class a privately owned sawmill which was the largest value in the town and which had its own protection was completely standardized.

In connection with towns standardized it must be remembered that this work included the standardization of all private plant equipment where possible or assistance given to private plants in the matter of providing proper adapters to interchange with the city hose. Similar information was furnished to towns which could not be standardized, and a check-up will be made on the question of whether these towns have provided the proper adapters as recommended.

In connection with the standardization work, considerable educational work was done on proper care of hydrants and hose in private plants and in the smaller towns with only volunteer fire departments. This included proper cleaning, drying, and racking of hose, and repair of couplings, nozzles and other fire equipment.

Information on fire drills was also furnished a number of volunteer fire chiefs in towns and private plants. The work, according to the records, has been considerably slower than quoted in some northern states but it must be understood that practically all the work was done with colored crews whose principal qualifications were strong backs rather than strong heads, and the engineer in charge had to do all the work of starting taps and dies.

It must also be remembered that the extremely warm weather of the past summer had considerable affect on the progress of the work, and that in several cases crews were "burned out" by the combination of heavy cuts and hot weather.

It is apparent from the record given above that only about 10 per cent of the towns of the state originally had National standard threads.

WARREN M. WELLS.[1]

Jackson, Miss.

[1] Mech. Engr., Mississippi State Rating Bureau. Assoc-Mem. A.S.M.E.

Unethical Use of Manufacturers' Drawings

TO THE EDITOR:

I was indeed pleased to read the article in the January issue of MECHANICAL ENGINEERING by W. W. Nichols in which he discussed the subject of the Unethical Use of Manufacturers' Drawings.

I feel that Mr. Nichols has brought out in his article some very vital points dealing with this subject of industrial concerns "pirating" the designs of different manufacturers which represent an outlay of large sums of money spent in very efficient engineering. I believe that the engineering profession of this country can combat this abuse of drawings if they cease placing in the hands of outside parties blueprints and drawings which show in detail the measurements of parts. Personally, I have seen some drawings which were so complete that all one would have to do would be to take it to the ordinary machine shop and have the mechanism made according to the drawing or blueprint.

Such practice places temptation before the small manufacturer, who perhaps is of the idea that he can manufacture this mechanism or machine more cheaply in his own tool department or factory than can the selling concern. If when blueprints or drawings are called for, a drawing of sufficient detail to present the main idea of the mechanism is submitted, there should be no necessity of sending a detailed drawing of each individual part, or of sending a drawing showing dimensions other than those indicating the floor space required, or dimensions for the connection to the power facilities.

There is in my mind but one real excuse for manufacturers furnishing detailed drawings to the trade, and that would be in the case of a user of mechanical equipment who was located thousands of miles from the plant which manufactured his machinery. Such a plant would necessarily need to have its own maintenance department, and due to the continual operation of the plant, would have to have their repairs done on very short notice. To such concerns, this practice of detailed drawings would, no doubt, be a logical course to pursue, but by the indiscriminate disbursement of detailed drawings it is certain that some of them will fall into the hands of manufacturers who are more interested in the advancement of their personal fortunes than in the advancement of engineering science.

By the elimination of this practice by all manufacturers it would soon become apparent to men who have been obtaining engineering service by such unfair means that the engineering profession was one of great importance and great necessity, and I venture to say that it would not be long until the engineers of America would be held in more respect and greater esteem by industrial enterprises.

Like Mr. Nichols, I would like to hear what some of the other engineers think of this matter.

D. LOREN DAVIS.[1]

Fort Madison, Iowa.

[1] Supt., W. A. Sheaffer Pen Company. Jun. Mem. A.S.M.E.

Progress in Printing

TO THE EDITOR:

Commenting further upon the report of the Printing Machinery Division, one feature of printing was not touched upon but is worthy of mention because it differs from practically all other lines of industrial effort.

The printer can make up *no* stock.

Each job is a special job for a particular customer and comes up in its present form but once. In newspaper and magazine work time enters as a leading factor to make each special job a rush job wherein an hour's delay may serve to render all the work previously done both void and obsolete. Machinery, equipment, and material-handling devices in profusion and perfection must therefore be in constant readiness to assure a victory in this fight against clock and calendar.

Printed matter is both the dress and the salesman of business in all walks of life, and yet, with the constant improvement in processes and scope and its ever higher standards, its cost has been kept at low levels through keen competition. It is not generally known, but in addition to domestic competition foreign printing (chiefly German) is getting a fair share of book work and mailing-list circulars. Against these barriers the printer has been enabled to carry on successfully by means of efficiency equipment upon which engineering has spent its best in design, research, and production.

Truly, as Mr. Vehslage says, "To win such recognition and appreciation...should therefore be one of the aims of the Printing Machinery Division." The engineer in printing machinery must correlate a number of different standards of measurement—the printer's inch being 0.996 in. and the working units fractions or multiples of this, while "type-high" is 0.918 in.; paper sizes and thickness are in a system peculiar to the paper trade, metric sizes entering to some extent, but the English system is the standard to which the structural work is done.

Add to this work in fields that are mechanical, electrical, chemical, thermal, and pneumatic—all or a part in a single machine—and the respect for engineers in this line needs must grow. High speeds are the rule, time and cost so demanding, and at these speeds sheets or webs of paper, slimsy and feather-light, must be handled accurately and positively.

Long before time study became popular and widespread in industry generally, the efficiency engineers of printing had developed a cost system of their own which has ever been a model of completeness and adaptability to both manufacturing and job work.

DONALD A. HAMPSON.[1]

Middletown, N. Y.

Gaging and Measuring Terminology

TO THE EDITOR:

The development and operation of gaging and measuring processes appear to be hampered by various interpretations of the terms employed. "Interchangeable," "tolerance," "allowance," "basic size," and "precision" each have two different meanings so far apart as to destroy the practical value of comparisons and calculations in which they appear together.

The A.E.S.C. Committee has defined these terms as applied to plain limit gages, but their definitions conflict with long-established practice in production by measuring means, such as micrometers. The limit-gage user and the micrometer user employ the same terms but with different meanings.

Both systems of size production are in very extensive use. Their fields overlap and they are rivals in most classes of quantity production. The use of micrometers in their present usual forms is impractical on some operations, as where the dimension is inaccessible. There are also conditions under which limit gages cannot be successfully used. But on most work of quantity production the fixed gage and the measuring instrument are in competition for the job. Recent developments of semi-automatic measuring instruments are affecting the situation.

It is evidently of prime importance that we have terminology for comparing and discussing these two systems, and for using their products exchangeably. The following is an attempt to analyze the situation and to suggest a remedy.

In the limit-gage system the production gage has fixed "go" and "not go" sizes. Only these extreme allowable or limiting sizes are shown on the drawings and represented in the gages. There is no best or average size recognized. It is assumed that all acceptable sizes are equally desirable.

In the measuring system, as with micrometers, the drawing gives the exact best or ideal size, while specifying the limits of allowable, usually occasioned and accidental, deviation.

The limit gage and its operation are therefore necessarily described in terms of extreme (worst acceptable) sizes, while the measuring system is in terms of the ideal size, with the extreme sizes merely accidental deviations. Terms which are significant and useful in the one system are not useful with the same meanings in the other system. The present confusion of meanings is doubtless due to the gradual development, in close association, of the two methods of size control in industry.

The obvious remedy is the employment of different terms in the two systems, retaining the old term in one and originating a new term, with suitable definition, in the other.

In determining which system shall retain each term we might weigh many considerations, such as the suitability of each definition to the name, and the age and extent of their association in mechanical literature. But, after all, the terms are arbitrary symbols and each must be exactly defined for the purpose now in view. The choice should be made from a practical consideration of actual conditions.

The standardization of plain limit gages is well advanced and broadly published, with exact definition of these terms as now applied to them. The measuring system is much simpler, and the adoption and definition of new terms for it will be relatively easy. There appears to be little doubt that all of these present terms should be retained in the limit-gage science, with the meanings which they now have there as defined by the standardizing committee.

There remains the assigning and defining of new terms for the exclusive use of the measuring system of production. In the following the new terms are only suggested and subject to discussion.

1 Let the micrometer user abandon "interchangeable" and adopt "exchangeable" as describing "mating parts which will assemble and function properly without fitting individual parts one to the other." (See *Machinery*, December, 1926, p. 319.)

"Interchangeability" as now defined in the limit-gage system, and to be retained there, appears to have a very different and highly technical meaning. It is a guarantee against over-tightness without consideration of over-looseness, or of complete ability to function. Interchangeable parts for force fit will surely go together, but they may fall apart in service. "Interchangeable" parts for a bearing may result in a clearance and oil film impractically thicker than desired.

2 Let the micrometer user abandon "basic" size and adopt "even" size. All holes will be exactly 1 in. or $1\frac{1}{8}$ in., etc., with least practicable variation above and below.

Taken by itself this term "basic" has this same meaning in the limit-gage system, but in actual application, in "hole basic" production, the average hole is larger. The "even" size is its extreme low limit. (See E. C. Peck, MECHANICAL ENGINEERING, December, 1925, p. 1165.) To combine production successfully from the two systems this must be accounted. To avoid serious risk of confusion it seems best to adopt separate terms as above.

3 Let the micrometer user abandon "tolerance" and adopt "deviation" as the maximum acceptable deviation from a specified exact size aimed at in the production of each piece.

This accidental and occasioned deviation in either direction is usually quite different in its practical effect from a numerically equal "tolerance" built into the working size of a limit gage and affecting every piece produced.

4 Let the micrometer user abandon fit "allowance" and adopt fit "difference" as the calculated exact amount to be added to the diameter of the shaft to produce the ideal force-in pressure in the ideal, even diameter of hole, or to be subtracted to produce the ideal clearance or oil film.

[1] Morgans & Wilcox Mfg. Co. Mem. A.S.M.E.

"Allowance," as now defined in the limit-gage system, and to be retained there, appears to have a meaning scientifically and practically quite different from this. It is the sum of the "difference" (a calculated fixed value) and the plus "deviation" (an extreme accidental error) in the other system.

5 Let the micrometer user abandon "precision" and adopt "accuracy" as expressing the quality of the product in terms of allowable extreme deviation, in a system of production aimed at an ideal size, with resulting close approximation to the ideal of the average size produced, and resulting also in a very small average error, plus and minus.

A numerically equal "tolerance" in the limit-gage system, where the distribution of sizes inside the extremes is random or worse, is usually not comparable with "accuracy" as above defined. This practical consideration reaches a maximum in producing parts for force fit where the tolerances or deviations required for quantity production exceed those permissible for assembly.

In this discussion the limit-gage system considered is that in use in this country, of only two fixed sizes, both of the extreme finally acceptable limits. Where the tolerated limits of inspection are wider than tolerance limits of production, as in British practice, the terminology must be extended in order to discuss and compare the practical advantages claimed for that method.

P. J. DARLINGTON.[1]

Boston, Mass.

A System of Limits for Different Kinds of Fits

TO THE EDITOR:

In the December issue of MECHANICAL ENGINEERING appears a letter by E. C. Peck, Chairman of the Sectional Committee on the Standardization of Plain Limit Gages for General Engineering Work, in criticism of certain features and statements in my article in the November issue on A System of Limits for Different Kinds of Fits.

The article in question represents an attempt at a more or less comprehensive review of fundamentals in which every effort was made to correctly and accurately use the technical terms involved. If the terms "allowance," "minimum and maximum clearance," and "minimum and maximum interference," are used as there defined, we would write for Loose Fits,

Min. Clearance $= 0.0025\sqrt[3]{d^2}$ instead of Allowance $= 0.0025\sqrt[3]{d^2}$

and for Medium Force Fits,

Max. Interference $= 0.0005d$ instead of Allowance $= 0.0005d$

The foundation equations so expressed are self-explanatory and avoid the necessity of defining allowance in a manner contrary to the old accepted use of the term. This is the only point involved in the "somewhat mild" criticism of the Sectional Committee's definition of the term "allowance."

Possibly the discussion of the hole and the shaft as bases for systems of fits would not have been criticized had not the German practice of two systems received favorable mention. The statement in favor of the German practice is simply the expression of a belief, right or wrong, that the universal adoption of a single system can not be secured. If a single system can be "put across" it would seem quite illogical to propose two, and if only one system is to be proposed it is quite clear that the article under discussion favors recommending a system based on the hole.

Some of Mr. Peck's criticism of the German practice does not seem entirely clear. Tolerances seem to be involved in his discussion of the hole or the shaft as a basis from which to work. If tolerances were not necessary and we had to deal only with allowances, it would still be necessary to decide on the hole or the shaft, and, in general, the arguments for or against either would be the same as now, and would hold with equal force. If the hole is decided upon as the basis from which to work, it would be logical to take the size of the hole equal to the nominal size. Since, actually, tolerances must be considered, it would next be in order to decide how to express them. If they are to be expressed unilaterally, the direction of variation from the basic size must be fixed. For good and sufficient reasons it is found better to vary the hold from basic to over basic rather than from basic to under basic. Likewise, if the shaft is taken as the basis from which to work up a system, it would be found better to vary from basic to under basic.

With respect to having two systems, it would seem to be putting the case much too strongly to say that it would result in "nearly as bad" conditions as to waste and inconvenience as existed in this country during the World War. Was not our trouble many, inconsistent, incomplete, poorly devised so-called systems, rather than two well-devised systems as against one? In writing a few pages of a book in 1921 the most comprehensive limit system the writer could find in English was the Newall System. The new British system became available in 1924; the A.E.S.C. system for the United States is not yet available.

It is stated that the author offers no proof in support of the statement that "Where the holes are so large that reamers would not be used, the shaft is a better basis for a system than the hole." Preceding this quoted statement the principal arguments in favor of the hole over the shaft as a basis for all cases where mass production methods are used, are given. If complete mass-production methods are not used and the arguments for the hole over the shaft based on gages, gaging, reamers, mandrels, etc. do not obtain, then it follows that the shaft is a better basis than the hole in so far as (to quote another sentence from the same paragraph) "The shaft as a basis does not break down and has no exceptions in application." Since it is clearly shown in preceding paragraphs how occasional exceptions for different kinds of fits on the same shaft can be easily accommodated under a system based on the hole, it would seem that the strength and weight of the arguments for the shaft are clearly indicated.

Mr. Peck states, "It is pointed out that often various fits are required on the same shaft and that the system proposed by the Committee does not admit this, etc." As a matter of fact, in discussing the merits of the hole as a basis, a simple illustrated example is given to show how easily and simply just such exceptions can be accommodated while still, for all intents and purposes, retaining the hole as a basis. It is to be noted, however, that the solution is to transfer to the shaft basis for the exceptional fit or fits. If for a product the exceptions are numerous enough, it would result in being, for all intents and purposes, on a shaft instead of a hole basis. The writer has in mind a machine product where, to reduce the cost of assembling and because of certain repairs and replacements, interchangeability for certain fits was very desirable. The design of the product necessitated the use of round cold-rolled stock in considerable quantities used as purchased. The great majority of the fits desired were between the bars and shafts and the frame members, bearings, and attachments. This being so, a limit system was devised using the shaft as a basis. Whether by redesign a system based on the hole could be used without having too many exceptions to deal with and without undue increase in cost, is another matter.

It is also stated that "Cold-rolled, turned, and ground shafting is, and always has been, from basic to under basic, and very rarely indeed can any be found up to basic, so that all of it will go into holes that are from basic to over basic." If this means to imply that the standard holes of the A.E.S.C. system are sufficient in number so that a selection can be made to yield the minimum clearances and maximum interferences of the fits of the system, the writer must disagree with the implication. Because a shaft will enter a hole is no guarantee that the resulting fit will be as desired.

In the third from the last paragraph Mr. Peck seems to infer that only those engaged in mass production and who aim at complete interchangeability are to be benefited by a standard system of limits. The writer believes that a well-devised standard system will prove of great benefit to the designers and builders of machines and mechanical products generally. Benefits to the producer or the consumer or to both can very often be secured by working to limits, whether all the parts of the product produced are interchangeable or not.

C. D. ALBERT.[2]

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MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers and Proceedings of

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Impediments to Patent-Office Effectiveness

A FORMER communication dealt with some of the housing and administrative conditions that interfere with the efficient operation of the Patent Office. Means of correcting those conditions were suggested. This editorial will touch upon other conditions that need correcting quite as much as those formerly treated.

CLASSIFICATION

The fundamental tool of a patent examiner is an accurate and comprehensive classification of all domestic and foreign patents and scientific literature. The size and importance of this tool may be appreciated when it is known that at the end of 1924 the number of patents issued in the United States was 1,531,000, and foreign patents had reached a total of 2,800,000.

No one knows how many articles have appeared in scientific literature, a classification of which should be at the disposal of the patent examiner.

The situation in the U. S. Patent Office today as regards classification is abominable. Some 56 classes, containing 321,000 patents, have not been revised since 1880. That is, 19 per cent of the existing classes have not been revised in 45 years or more. Over 63 per cent of all classes have not been revised in over 10 years.

In practically none of the 242 classes which have been revised since 1898 has the class referencing been kept up as it should be.

Foreign patents are not classified by the Classification Division, but are assigned by the Scientific Library to the examining divisions. The examiners in each division classify them for their own use without any uniform plan or guidance.

The situation as to classification of patents is perhaps the most serious impediment to the work of examiners. It should have immediate attention.

NUMBER OF CLAIMS

To a degree each claim set forth in an application for a patent requires approximately the same amount of the time of an examiner as does every other claim. Therefore, broadly speaking, an application containing fifty claims will require twice as much time to examine it as will an application containing only twenty-five claims. It is not unusual for applications to contain several hundred claims.

Some patent attorneys have adopted the pernicious practice of multiplying the number of claims by a system of combinations and permutations. They write four or five basic claims and give these to a clerk, who, with a table of combinations and permutations, develops as many claims as possible. This practice increases the work of the Patent Office enormously. It is both wasteful and abominable. The Committee on Patent Office Procedure will recommend that a definite number of claims be accepted with the filing fee and an extra charge be made for each claim above the fixed number allowed. The results of such a ruling measured in quantity and quality of output will be invaluable.

TECHNICAL-EMPLOYEE SEPARATION

It is generally conceded that it requires from four to five years to train a new recruit to become a responsible and reliable examiner. To give a man such training is expensive, and it is a serious matter to lose him after he is trained. Yet this is happening almost daily.

On May 1, 1925, there were 617 members of the technical staff of the Patent Office. Of this number 27 per cent had been in the service one year or less; 54 per cent for four years or less; 74 per cent for ten years or less. Only 26 per cent had been in the service more than ten years. Any executive in charge of a technical staff would readily view with alarm such a loss of technical men, especially when it required approximately five years to train them. What is happening is that a number of young men enter the Patent Office and at once begin to study law at some university in Washington, which study they complete in from three to four years. Upon the completion of their law course they leave the service. From March 20, 1922, to May 1, 1925, there were 217 resignations. Of this number 68 per cent had been in the service four years or less.

To correct this very trying and ineffective situation at least two things should be done. First, there should be instituted a thorough and a systematic course of training for all new recruits. The objective should be to so train a recruit that he would be a reliable and responsible examiner in much less than five years, the time now required. This would result in obtaining more output from that large group which leave the service in four years or less.

The second thing to be done is to increase the salaries of examiners. Patent examiners are skilled men, and most of them hold two or more degrees. Practically all of them are scientific and legal graduates. The scale of salaries paid is much lower than such men are entitled to through sheer justice. It is not difficult for them to make many times more in industry or private practice. That they can is evidenced by the large number that sever their connections with the Patent Office.

The salary situation could be improved by a more liberal policy of classifying examiners under the Personnel Classification Act. By the rules laid down under the Act many of the examiners are placed in lower salary brackets than should be the case. There is not sufficient liberality in the way of promoting examiners so they may obtain the benefits to be derived from the higher salary brackets.

LEGAL REQUIREMENTS AND RULES

There are certain legal requirements and Patent Office Rules of Procedure that serve as detriments to expeditious and satisfactory work. The Committee on Patent Office Procedure will make some recommendations. The author does not feel competent to discuss these things and space will not permit. Suffice it to say that in the minds of many thoughtful men these aspects of the situation are serious and demand immediate correction.

SUMMARY

In concluding this series of articles it is well to briefly summarize the outstanding changes that should be brought about in order that the Patent Office may more satisfactorily discharge its functions. The order in which they are named has no particular significance. All are exceedingly important.

1 Define more sharply the line of demarcation between the administrative and the judicial functions of the Patent Office, and particularly fill each position with men specially qualified.

2 Build a new Patent Office building designed for that particular type of work, and provide it with modern, standard, and fireproof equipment.

3 Complete and keep correct a thorough classification of all domestic and foreign patents and scientific literature.

4 Institute and enforce rules and regulations whereby the needless multiplicity of the number of claims will be eliminated.

5 Organize and conduct a comprehensive course of training for all new technical recruits so they may become really effective within one or two years instead of from four to five as is the case now.

6 Increase the salaries of examiners and bring about a more liberal personnel classification, so that the services of the technical men may continue for a longer period of years.

7 Amend, repeal, or revise all statutes and rules that interfere with the expeditious functioning of the Patent Office or contribute to patent litigation.

Unless some aggressive steps are taken in the near future, the entire patent system will be jeopardized. Therefore may the writer be permitted to again urge a careful study of the situation by all concerned so that intelligent concentrated efforts may be directed toward an early solution.

L. W. WALLACE.[1]

Industrial Safety

THE January issue of the Annals of the American Academy of Political and Social Science is a timely compilation of papers prepared by authorities of national fame and covers the entire industrial-safety movement. The editor, Hon. Richard H. Lansburgh, and his co-authors, among whom are William Green, president of the American Federation of Labor, Magnus W. Alexander, president of the National Industrial Conference Board, Inc., and Dr. P. G. Agnew, secretary of the American Engineering Standards Committee, should excite the interest of even the most casually interested industrial executive.

Industrial safety is an ancient and honorable effort which, Mr. Alexander points out, Moses recognized in the following injunction: "When thou buildest a new house then thou shalt make a battlement for thy roof, that thou bring not blood upon thine house if any man fall from thence." The Industrial Revolution introduced machinery and with it introduced new risks multiplied by the increased interdependence of the workers. The safety of an employee depended not only upon his own prudence and judgment, but also upon the prudence and judgment of his fellow-employees and upon the foresight of the employer in detecting hazards inherent in the new mechanical devices.

It is axiomatic that industrial safety is one of the great economic problems of the United States, and the volume reviewed has been developed to meet the need for a compilation of articles on its various phases.

As stated in the foreword, "Twenty to twenty-five thousand are killed annually while in the course of their employment. Two million of us are suffering non-fatal accidents of varying degree." Thus that accidents are a form of economic waste has been clearly established. "This vast loss in man power must be replaced, and that replacement cost may range from $10 to $200 per individual. Moreover accidents cause a temporary stoppage and readjustment of production, with respect to which employers cannot afford to be indifferent."

"Employers have not, in recent years, been unwilling to recognize their responsibility for the protection of their employees."

The widespread recognition of this phase of industrial life assumed a position of importance in about 1907, and during the period between 1907 and 1917 the iron and steel industry brought about a reduction in the frequency rate of accidents of sixty-seven per cent, and the severity rate, measured by the number of days lost, declined sixty-two per cent.

The rapid growth of the safety movement has been partly due to the demonstrable fact that accident prevention pays, hence there has been effort and definite analysis of accident causes, reducing the accident toll from mechanical power and transmission equipment to a comparatively low point as compared to the many persons injured by non-mechanical means.

It has furthermore been demonstrated that certain hazards or accidents can be reduced to insignificance, such as accidents to the eye, industrial poisoning, and cases of infection, through guarding danger points, well-diffused illumination, and immediate and skilled first aid. The education of the worker is especially necessary, and the industrial managers must be particularly conspicuous in promoting the interest of the worker in the safety movement.

"It is probably not an exaggeration to say that fifty per cent of all industrial accidents would be prevented if the worker had safety actively before him. Putting safety across to the worker must be done largely through the foreman. Most safety work, most guarding, most expenditures for safety go for naught unless the worker himself understands the safety problem. When seventy-five per cent of the workers in industrial plants become actively interested in safety, accidents will be halved."

This volume contains many charts. The articles applying to specific industries, such as steel, coal, cement, railroads, buildings, chemical, textile, etc., are recommended to the attention of those specializing in these particular industries. A brief review cannot do adequate justice to such a valuable treatise, which is recommended to those who chance to read this review.

ROBERT E. NEWCOMB.[2]

Lead-Treated Gasoline

FOLLOWING a number of accidents to workmen engaged in the manufacture of tetraethyl in New Jersey and Delaware in April, 1926, Surgeon General H. S. Cumming, of the U. S. Public Health Service, appointed a committee to investigate the entire subject of the safety of use and manufacture of this material. The Committee consisted of representative men in the medical profession.

Contrary to the usual method of investigation in such cases, the tests were made not on animals such as rabbits or guinea pigs, but on human beings. The conclusions at which the Committee arrived were that gasoline treated with tetraethyl of lead may be used safely provided certain precautionary measures are carefully enforced. What these precautionary measures are has not been stated by the committee. But it is suggested that the various health officials of the country meet with the committee or with the U. S. Public Health Service to draft the necessary measures.

The committee adds, however, that—

> It remains possible that if the use of leaded gasolines becomes widespread, conditions may arise very different from those studied by us which would render its use more of a hazard than would appear to be the case from the investigation. Longer experience may show that even such slight storage of lead as was observed in these studies may lead eventually in susceptible individuals to recognizable lead poisoning or to chronic degenerative diseases of a less obvious character.
>
> In view of such possibilities the committee feels that the investigation begun under their direction must not be allowed to lapse. The respective states would be dependent upon the findings of such investigations for changes in their regulations. With the experience obtained and the exact methods now available it should be possible to follow closely the outcome of a more extended use of this fuel and to determine whether or not it may constitute a menace to the health of general public after prolonged use of other conditions not now foreseen.
>
> Outside the question of ethyl gasoline, it would seem from this investigation that wherever automobiles are housed together there is an accumulation of lead dust which may prove to be a source of danger to the workers involved, in addition to the hazards arising from the production of carbon monoxide gas. The vast increase in the number of automobiles throughout the country makes the study of all such questions a matter of real importance from the standpoint of public health, and the committee urges strongly that a suitable appropriation be requested from Congress for the continuance of these investigations under the supervision of the Surgeon General of the Public Health Service and for a study of related problems with the use of motor fuels.

It should be clearly understood that the work of the Committee dealt exclusively with the use of lead-treated gasoline, i.e., material containing roughly one-tenth of one per cent of tetraethyl of lead. It did not deal at all with the processes of manufacture of the lead product itself.

The Committee has also suggested that means such as coloring lead-treated gasoline red be adopted to prevent its use in such industries as dry cleaning.

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Spain to Argentina by Air

IN THE past month a daring attempt to fly from Spain to Argentina has been made by a Spanish flier, Commander Ramon Franco, and his gallant crew. The flight is of interest as it involves several hops of considerable length, one to Fernando de Noronha, 1492 miles. Notwithstanding the great length of the individual hops over open and comparatively little-traveled parts of the Atlantic Ocean, no special precautions such as were made during the N C flights of the U. S. Navy across the Atlantic, were taken. Had the Spanish aviators been forced to come down, they might have been in considerable danger. Fortunately for them, they made each hop without any trouble or accident.

The average velocity of the flight is slightly in excess of 100 miles an hour, which is quite good for a large machine equipped with substantial floats. The plane which they flew was a Dornier-Wal equipped with two Napier-Lion motors. Commander Franco is an expert long-distance flier and has been in the Spanish Army as aviator for a number of years.

The flight is interesting in showing the high state of reliability which aviation is beginning to attain.

Guggenheim Fund to Promote Civil Aviation

RECOGNIZING that there is an intervening period of study and experimentation before civil aviation in the United States can realize the possibilities that lay before it, and desiring to assist during that period, Daniel Guggenheim established a fund of $2,500,000 for the promotion of aeronautics. In his announcement of the gift Mr. Guggenheim emphasized "the urgent need for immediate practical and substantial assistance to aviation in its commercial, industrial, and scientific aspects. No less urgent is the need to awaken the American public, especially business men, to the advantages and possibilities of commercial aircraft—in a word, to make the American public in a very real sense 'air-wise.'" The general purposes of the Fund are:

1 To promote aeronautical education both in institutions of learning and among the general public
2 To assist in the extension of fundamental aeronautical science
3 To assist in the development of commercial aircraft and aircraft equipment
4 To further the application of aircraft in business, industry, and other social and economic activities of the nation.

The fund has been incorporated as the Daniel Guggenheim Fund for the Promotion of Aeronautics and ten directors have been elected, namely, Rear-Admiral H. I. Cone, F. Trubee Davison, Dr. William F. Durand, Gen. George W. Goethals, Harry F. Guggenheim, A. A. Michelson, Dwight W. Morrow, Elihu Root, Jr., John D. Ryan, and Orville Wright. Harry F. Guggenheim is president and Rear-Admiral Cone, vice-president and treasurer.

A tentative report on program indicates that the possibilities for the use of the Fund lie in four fields: education, scientific research, commercial development, and educational information.

Under "education," activities might lead to the popularization of aviation in the high school by the loaning of educational films, by instruction of manual-training teachers in the details of aeronautical construction, by preparing pamphlets on the construction of models and simple aircraft parts, and by the promotion of gliding. Lectures on general aviation subjects before the seniors in civil and mechanical engineering at universities and technical schools offer another opportunity for education. A third possibility is the establishment of aeronautical schools and the development of post-graduate courses. Other opportunities include the donation of equipment, the establishment of fellowships, instruction in the aeronautic trades, prizes for papers, and the publication of bulletins and special texts.

The field for scientific research is unlimited, but the Fund does not desire to build up its own research organization but rather to work through existing institutions. The Fund might select certain problems in fundamental aerodynamics or in applied science and finance their research. Typical examples would be the helicopter and radio direction finders and leader cables.

To encourage the development of commercial planes, the Fund might hold contests and offer prizes or set up specifications for ideal planes and contract for their design as an economic demonstration.

The Fund might supplement the daily press accounts of aeronautical events by explanations of the fundamentals involved through popular lectures and accurate statements to the press. The collection of authoritative data for writers seeking material, and the dissemination of information on developments in commercial aviation both in this country and abroad to the general public, furnish excellent opportunities for the stimulation of the popular interest in the progress of aviation.

Aeronautic Safety Code Approved as U. S. National Standard

AFTER five years of work, a joint technical committee of fifty experts representing twenty national organizations has completed a safety code for aircraft, which includes traffic rules for the air, signals, qualifications for pilots, and regulations for the design, manufacture, testing, and operation of all types of aircraft and their equipment.

This code has been given final approval by the American Engineering Standards Committee, thereby making it a national American standard.

"The value of specific regulations dealing with the various factors entering into the problem of safe aviation," it was stated by the Committee in announcing the approval of the Aeronautic Safety Code, "is shown by the fact brought out by the Department of Commerce that accidents are much greater among the so-called 'gypsy fliers' than with aviators carrying mails or working for some reputable aviation corporation. The inherent hazards of flying are in themselves sufficiently great, and there is no warrant for unnecessarily subjecting pilots, passengers, and the public to hazards which can be eliminated by giving proper attention to the result of past experience and present knowledge.

"The Aeronautic Safety Code formulates the standard of good practice on which a general agreement is possible and will undoubtedly prove a valuable guide to the design, construction, and operation of both airplanes and dirigibles, and will form a basis for the rules of any public authority regulating air traffic that may be constituted in the future.

"The technical committee has coöperated with the International Commission for Air Navigation in order to make the code generally consistent with the International Air Convention, and with the work of the Commission, since the international aspects of aviation are bound to be of increasing importance as the art develops."

The Aeronautic Safety Code consists of the following ten parts:

1 Airplane construction
2 Power plant
3 Equipment, maintenance, and operation of airplanes
4 Signals
5 Airdromes
6 Traffic and pilotage rules
7 Qualifications for airmen
8 Balloons
9 Airships
10 Parachutes.

Among the traffic rules are the following:

1 Aircraft meeting head on shall pass to the right of each other.
2 One aircraft overtaking another shall pass to the right.
3 An aircraft is considered in dangerous proximity to another when approaching in flight within 1500 ft.
4 Airplanes shall yield the right of way to dirigibles, and dirigibles shall yield to balloons.

The joint technical committee which drew up the code was organized under the leadership of the U. S. Bureau of Standards and the Society of Automotive Engineers. The Federal Government is represented on it by the War, Navy, and Post Office Departments, the Bureau of Standards, the Weather Bureau, the Forest Service, and the National Advisory Committee for Aeronautics. The other thirteen participating organizations are technical and

trade associations. The American Society of Mechanical Engineers was represented on the committee by E. P. Warner.

The chairman of the committee is H. M. Crane, Society of Automotive Engineers; the vice-chairman, J. H. Ames, National Advisory Committee for Aeronautics, and the Secretary, M. G. Lloyd, Bureau of Standards.

This committee continues in existence in order to make future revisions of the code from time to time as they may appear necessary by progress in the art or as the result of experience in applying the code in commercial aviation.

Progress in Education Investigation

EXCELLENT progress is reported in the investigation of engineering education being conducted by the Society for the Promotion of Engineering Education under an appropriation from the Carnegie Corporation. An abstract of the Report of the Director, W. E. Wickenden, and Associate Director, H. P. Hammond, follows.

In reducing the history of the Society's investigation to its simplest outlines, the year 1924 may be characterized as a period of reconnaissance, contact making, and preliminary organization, culminating in the official statement of objectives; 1925 has been a year of fact gathering, both at home and abroad, and of preliminary diagnosis of the situation; while 1926 is yet available for the reaching of conclusions and the initiation of constructive action. The data-gathering process is still going forward. Its present state is set forth in the accompanying tabulation.

Participation by the Colleges. During the academic year of 1924–25, 114 colleges in the United States and Canada were affiliated in the project through coöperative committees of their faculties or through designated individual correspondents. Considering the large number of institutions, their diversity of types and organizations, and their wide geographical distribution, the unanimity and excellence of the response to our requests for coöperation have exceeded our most optimistic expectations. This remarkable evidence of interest in the Society's project is believed to indicate a growing desire among the colleges for concerted effort and a gratifying degree of confidence in the manner in which the general project is being conducted.

To date in the academic year 1925–26, 130 colleges in the United States and Canada have become affiliated through the means previously mentioned. As there are now 515 individual members of coöperative committees and correspondents in the affiliated colleges and 37 members of the five general committees of the Society, the direct participation of engineering teachers is very extensive.

While the work of gathering data is still going forward, the principal effort of the present college year is to obtain widespread study and discussion of the accumulated material, with a view to informing the teaching staffs of the present situation and to obtaining suggestions as to developments and betterments needed. Upon receiving notification of the appointment of each coöperative committee for the present college year, a letter was addressed to the chairman outlining a program through which the study and discussion of the published data could be effected. In order to facilitate the presentation of the data, much of the information has been reduced to graphical form and reproduced as lantern slides. Sets of these slides have been prepared for circulation among the colleges and the committees notified of their availability. There has been a prompt and widespread response, and the slides are being booked by institutions in all parts of the country.

Program of the Committees of the Society for 1925–26. During the academic year of 1924–25 four committees of the Society sponsored the various projects of fact collection which were undertaken by the faculty committees. During the present year these general committees have turned from the fact-gathering phases of the undertaking to the work of interpreting the data, and are now engaged in the preparation of final reports which will set forth their views as to developments needed in the fields of their respective assignments.

A fifth committee of the Society, charged with a study of the economic content of engineering education, has been organized under the leadership of Prof. H. E. Riggs, of the University of Michigan, as chairman, and Dean W. G. Raymond, of the University of Iowa, as secretary. The creation of this committee is an outgrowth of the studies of last year which revealed the strong belief of many graduates and practicing engineers that the economic phases of engineering are not reflected in engineering courses to the same degree as the technical phases, and that engineering education thus lacks a proper degree of emphasis on one of its essential aspects.

Participation by the National Engineering Societies. The most active work during 1925 has been done by The American Society of Mechanical Engineers, which carried through an extended study as a direct contribution to the Society's general project. This study dealt with the general questions of specialization, administrative training, and relations between the engineering societies and the colleges with particular reference to mechanical engineering. A report of this study was presented at a general session of the annual meeting of the A.S.M.E. and will be published for general circulation.

The American Institute of Electrical Engineers has made an appropriation for a similar study. A special committee of the American Society of Civil Engineers headed by Dean Anson Marston has taken initial steps to obtain funds for a like purpose.

Participation by the United States Bureau of Education. The studies of curricula and entrance requirements of engineering colleges have been completed and are ready for publication. The services of Dr. Walton C. John in this connection have been a notable factor in the general project.

Study of Engineering Education in Europe. The Director devoted eight months of 1925 to this major division of the general project and is now engaged in the preparation of a report covering the items indicated under this heading in the accompanying summary.

Collateral Investigations. The study of engineering education and the manufacturing industries conducted by the National Industrial Conference Board has reached an advanced stage. The data have been assembled and are being incorporated into a comprehensive report presenting an authoritative survey of the state of supply and demand, and of opinions of industrial leaders with reference to technically trained man-power in industry. The appearance of this report bids fair to be an event of first magnitude in engineering education.

The study of engineering education and the railroad industry under the auspices of the American Railway Engineering Association has made substantial progress. A trial survey of the supply and recruitment of technically trained men has been carried through in a single railroad organization and provides a model for a very extensive survey for which funds have been made available.

U.E.S. Library Reports Successful Year

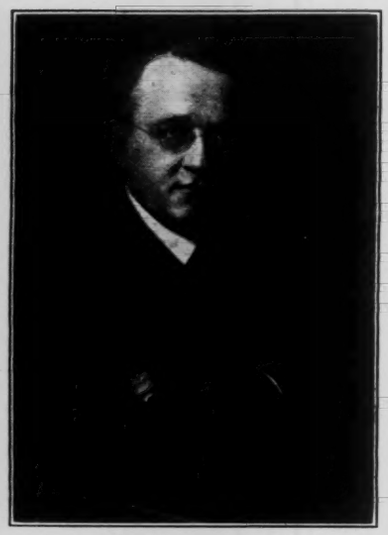
THE Annual Report of the Library Board showed a splendid increase in the service rendered to the members of engineering societies during 1925.

In presenting the report of the Director, Harrison W. Craver, Sydney H. Ball, Chairman of the Library Board, pointed out the need for expansion of the physical facilities and of the financial resources of the Library to meet the needs of the future.

In his report Mr. Craver stated that at present the Library has on its shelves 101,029 volumes, 3370 pamphlets, 1800 maps, and 4120 searches, giving a total of 110,319. During the year the additions were 3746 volumes, 818 pamphlets, 159 maps, and 129 searches, or a total of 4852. These additions included a number of early works on electricity, railroads, and mining and civil engineering.

During the year the number of readers was 25,354, of whom 5002 used the Library in the evenings. The service desk answered 4424 telephoned inquiries, also an increase of 8 per cent over 1925. The Library lent books by mail to 79 members and to 125 members who visited the building, a total of 204. The number of books lent was 237, of which 33 were purchased by the borrowers. Lending has been greatly appreciated by those who used it. Except when nothing was in print on the desired topic, the requests of members have been met. The search department made searches for 238 persons and translations for 96. The photoprinter made 27,373 photoprints for 2666 orders. In these various ways the Library was used by 35,511 persons.

Dr. Parke Rexford Kolbe Inaugurated as President of Brooklyn Polytechnic Institute



ON WEDNESDAY evening, January 13, 1926, there took place at the Academy of Music in Brooklyn, N. Y., an impressive ceremony of much interest to a great number of engineers. This was the inauguration of Dr. Parke Rexford Kolbe as president of the Polytechnic Institute of Brooklyn. This is one of the oldest colleges of engineering in the United States, having been established in 1854.

Dr. Kolbe was graduated from Buchtel College in 1901 and received his master's degree there the following year. In 1912 he was awarded the degree of Ph.D. by the University of Heidelberg. Dr. Kolbe comes to the Brooklyn Polytechnic Institute from the Municipal University of Akron, which he has served as president for the past twelve years and done much to build up. He was a member of the Federal School Survey Commission to the Hawaiian Islands in 1919, and was head of the U. S. Bureau of Education Survey Commission to the University of Arizona in 1922. He is also widely known as a writer upon educational subjects.

The audience which gathered in the Academy was a large and distinguished one. Among those present were a hundred and sixty-one delegates, representing one hundred and forty-seven colleges and universities, and thirty delegates representing twenty-seven scientific and engineering societies. The American Society of Mechanical Engineers was represented by its Past-President, Dr. D. S. Jacobus, who had been appointed Honorary Vice-President for this occasion. Charles E. Potts, chairman of the Board of Trustees, was the presiding officer. After the prelude and invocation, William H. Nichols delivered an address on behalf of the Institute Corporation, of which he is the vice-president. He traced the history of the Institute from the time of its organization seventy two years ago, and extended a cordial welcome to Dr. Kolbe.

George Stuart Collins, Ph.D., as senior professor, then delivered an address on behalf of the faculty, in which he pledged the hearty support of the teaching staff.

The alumni were represented by Bancroft Gherardi, of the class of 1891, who is chief engineer of the American Telephone & Telegraph Company. After some reminiscences upon the state of engineering progress during his college days and contrasting conditions of today, Mr. Gherardi paid tribute to those graduates of technical schools who have done so much in bringing about the remarkable progress of the past three decades. In his closing remarks, Mr. Gherardi said:

> No one who has given thought to the question believes that we have reached the end. I am convinced that if we could move a few decades ahead in time and look back over the intervening period we would see further advances comparable with, and perhaps exceeding, those which have taken place in the past years. I am satisfied that as time goes on we shall regard the achievements of today as only the small beginnings upon which progress has been built.

Edwin Zipse, of the class of 1926, president of the Student Council, delivered an address on behalf of the student body. He called attention to the fact that this student body is unique in that it is a most cosmopolitan group, representing an extraordinary number of races and religions, but bound into a strong democracy. Most of them were not rich except in enthusiasm, and this was pledged to Dr. Kolbe.

The principal address of the occasion was that of Charles A. Richmond, DD., LL.D., president of Union College and chancellor of Union University.

Dr. Richmond spoke on behalf of all the colleges represented at the inauguration. He "broke the ice" by giving Dr. Kolbe an insight into the conditions which he was about to face, and at the same time assured him that while in the reserved manner of the East he might not generally be called by his first name immediately, as may have been done in the less conventional communities of the Middle West, the welcome was none the less sincere.

In the course of his remarks Dr. Richmond said:

> The institution over which you are to preside is called "Polytechnic." But this does not mean that the aim and end of it is exclusively and narrowly technical. The fact that it is polytechnic indicates that its range is wide and that its culture is many-sided, although we have to call in a Greek word to explain that significant fact. Nor does it mean that its function is discharged in the mere training of young men to the practice of a profession.
>
> The old-fashioned classical college has largely given place either to the great university or to the type of institution whose function is to fit young men for a special calling. But even this is not modern. All the earliest universities grew out of the demand of some specific need. It was the needs of the human body which originated Salerno, the oldest of all, going back before the days of Charlemagne in 800 A.D. It was the needs of men as related to each other in a civil organism which originated in Bologna about 1100. It was the eternal needs of the human spirit in its relations to the universe that originated in Paris a little later. And so men were furnished for the three professions of medicine, law, and theology—once justly called the learned professions.
>
> But none of these great schools were narrowly professional. They were a great intellectual force acting in all directions. In our own country, as you know, our oldest universities were endowed by their founders for the training of young men for the gospel ministry. Today only an insignificant number of men go out from these institutions into this anachronous but still reputable calling. Does the community no longer need ministers, or is it just that people do not hanker after them as they used to in the simpler days of our republic?
>
> Anyway, times have changed; learned professions tend to become trades and heavy hands have battered in the gates and even threatened Minerva in her own shrine. These changes have come because there has been what we call a demand for them. But a demand does not always rise out of a real need. My own feeling is that our institutions of higher learning have yielded too much to cheap popular demands. A very important function of an institution such as this is to make people want what they need. It is the crux of all teaching, as every teacher knows.

Upon the conclusion of Dr. Richmond's address, Charles E. Potts, the presiding officer, presented Dr. Kolbe with the charter, seal, and keys. After reading a cordial letter from the retiring president, Fred W. Atkinson, who was unable to be present, Mr. Potts gave a review of the accomplishments of Dr. Kolbe, describing him as a splendid man of unquestioned ability, unusual vigor, and sanity. The ancient form used in installing the president followed this tribute.

Dr. Kolbe responded with an inaugural address in which he demonstrated his wide knowledge of the subject of education, and showed that he has a thorough understanding of the particular problems affecting the future of the Brooklyn Polytechnic Institute. Among Dr. Kolbe's remarks the following are particularly worthy of notice:

> As a preliminary to further analysis I would repeat here the often-stated and little comprehended fact that our system of higher education, in large part free to all who desire it, is a unique experiment. In this respect we stand alone among nations. Compared to 132,000 students in Germany, 80,000 in France, and 31,000 in England, the United States has 664,000 students in its colleges. The figures just given are naturally subject to the inaccuracies attendant upon the comparison of dissimilar systems of education. In the main, however, they show beyond question that this country is not only dealing with much greater numbers of students than any other country, but that it is going down much deeper into its population to recruit its college material.
>
> Most of our efforts have been practical and desirable, since they have been honestly based upon the desire to improve the student's training and character, and only secondarily upon any possible immediate gain to industry or college.
>
> Whether the products of the creative mind are always adequately estimated is more doubtful. There is unquestionably a tendency to magnify the practical application and minimize pure research. Mr. Ford was

recently quoted by the New York *Times* as saying: "Patents are silly things when they are used to hinder any industry. No man has a right to profit from a patent only. That produces parasites, men who are willing to lay back on their oars and do nothing. If any reward is due the man whose brain has produced something new and good, he should get it through profits from the manufacture and sale of that thing." Doubtless this is sound commercial reasoning, but there is something in the wording of the last sentence which makes one hope that Mr. Ford has been incorrectly quoted. Surely no such limitations surrounded the work of a Pasteur or the researches of a Steinmetz.

Specifically, then, the modern college of technology must have, first of all, the right to choose as entrants only those who are well prepared in the basic preliminary subjects; second, the sympathetic interest of industry in the training of its students, and third, the assurance that its graduates shall have reasonable opportunity to continue their mental development and to receive a fair measure of return for their productive effort. Its highest function and privilege, however, is the discovery and development of the creative intellect.

John Fritz Medal Awarded to Edward Dean Adams

ON JANUARY 15, the John Fritz Medal Board awarded its gold medal, the highest honor bestowed by American engineers, to Edward Dean Adams for achievement as "an engineer, financier, scientist, whose vision, courage and industry made possible the birth at Niagara Falls of hydroelectric power." The presentation will be made on March 30.

Mr. Adams was graduated as a bachelor of science from Norwich University in 1864, and afterward pursued engineering studies at the Massachusetts Institute of Technology. He has been a fellow of the American Society of Civil Engineers since 1891, an associate of the American Institute of Electrical Engineers since 1910, vice-chairman of Engineering Foundation from its beginning, and for years an active member and officer of the Engineering Societies Library Board.

It was on his decision that alternating current was chosen for the epoch-making plant of The Niagara Falls Power Company in 1891, and for the transmission of power by wire to Buffalo.

Mr. Adams is a member of the National Research Council, and of the American Museum of Natural History. He has also been a patron of the fine arts in this and other countries, and for many years a trustee of the Metropolitan Museum of Art.

Most of his long and active business life was devoted to large enterprises combining engineering and finance. He had a leading part in the organization and reorganization of numerous railroads, including the West Shore, the Central of New Jersey, the Western Maryland, and the Northern Pacific. He created the American Cotton Oil Company out of innumerable small companies; led in establishing the All-American Cables, and had an important share in many another industrial undertaking. For fifteen years he was a member of the banking firm of Winslow, Lanier & Company, and for twenty-one years American representative of the Deutsche Bank of Berlin.

Armour Institute to Merge with Northwestern University

AGREEMENT has been reached by which Armour Institute will be merged with Northwestern University in an enlarged engineering department which will bear the name of the Armour College of Engineering of Northwestern University. A five-year period will be required for the completion of the project, which will include enlargement of dormitory facilities of Northwestern University at Evanston, the expansion to three times its present size of Swift Hall of Engineering, which now houses the Northwestern Engineering School, and the construction of one additional machinery hall and two new science buildings on the Evanston campus, and one machinery hall on Northwestern's downtown campus to accommodate part-time students who will number between 800 and 1000.

In statements commenting on the merger, President Scott of Northwestern University and President Raymond of Armour Institute pointed out that the constant expansion of the Mississippi Valley will require competent, well-trained engineers, the demand for which the new engineering institution will be able to satisfy.

Investigation of Railway Brakes

THE American Railway Association is now conducting an investigation of brakes and appliances for operating power brake systems for freight trains. This investigation is being carried out to determine whether improvements desired by the Interstate Commerce Commission can successfully be provided. Steps have been taken to secure appliances to meet the views of the Commission. These appliances will be given exhaustive tests on the 100-car test rack at Purdue University, which will be brought up to date for the purpose of the investigation. On the completion of the rack test, road tests will be carried out.

Drastic Reorganization of Government Service Proposed

CONGRESSMAN Martin L. Davey has introduced a bill in Congress to give the President of the United States full authority for two years for the purpose of reorganizing the Government service.

The bill as presented by Congressman Davey authorizes the appointment of an advisory reorganization board which shall be empowered to advise the President as to unnecessary and useless employees, divisions, bureaus, and commissions of the Government. The bill sets aside the civil-service status for all Government work, which, however, may be restored after this period by presidential proclamation. Mr. Davey hopes that by such drastic steps inefficient employees may be removed and opportunity may be given for suitable recognition of the many faithful, meritorious Government workers.

Salary Curves of Recent Mechanical Engineering Graduates

DIRECTOR R. H. Fernald, of the Mechanical Engineering Department of the Towne Scientific School, University of Pennsylvania, made an analysis of the records of salaries received by 220 recent graduates of that department. The following is a summation of the report:

Of the mechanical engineering graduates of the classes of 1913 to 1914, inclusive, whose addresses were known, returns were received from 86 per cent—a very remarkable response.

The salaries recorded do not include inherited incomes or incomes from miscellaneous sources, but represent straight salaries or earned incomes of graduates.

The average earned income for the first year out of college for the class of 1924 was more than double that of the class of 1913, a fact which would be expected in view of the relative values of the dollar for the two dates indicated.

An examination of the curves giving average incomes for the classes 1913 to 1920, inclusive, shows clearly the reactions due to the war, as there is a distinct change in the slope of each curve immediately following the close of the war. The upward trend of the last two or three years is also very marked.

A brief summary of the salaries received the fifth year after graduation (classes 1913 to 1921, inclusive), is as follows:

2 per cent are receiving $5000 to $6000
6 per cent are receiving $4000 to $5000
32 per cent are receiving $3000 to $4000
44 per cent are receiving $2000 to $3000
16 per cent are receiving $1000 to $2000

A brief summary of the salaries received the tenth year after graduation (classes 1913, 1914, and 1915) is as follows:

11 per cent are receiving $10,000 to $13,000
7 per cent are receiving $ 7000 to $ 8000
2 per cent are receiving $ 6000 to $ 7000
13 per cent are receiving $ 5000 to $ 6000
11 per cent are receiving $ 4000 to $ 5000
38 per cent are receiving $ 3000 to $ 4000
18 per cent are receiving $ 2000 to $ 3000

Of the classes of 1913 to 1917, inclusive, of 83 men reporting,

41 per cent are receiving $5000 or over
20 per cent are receiving $7000 or over
10 per cent are receiving $10,000 or over.

For 1925 conditions, the average annual salary for the first 7 years out of college may be expressed by the following formula:

$$S = 1500 + 300\,y$$

in which y is the number of years out of college.

The Boiler Explosion on the S.S. "Mackinac"

ON AUGUST 17, 1925, one of the boilers of the steamer *Mackinac* exploded while the vessel was in Narragansett Bay on its way from Newport to Pawtucket, R. I., resulting in the death of 52 persons and the injury of over 100 others.

The *Mackinac* was built in 1909 on the Great Lakes and was operated there until 1924. It was then put on an excursion route for the summer and at the time of the explosion was carrying nearly 700 excursionists.

As shown in Fig. 1, the boilers on this vessel are of a rather unusual type said to be peculiar to lake boats. The upper part is similar to a return tubular boiler, but in place of a setting, the firebox and combustion space are enclosed by water legs which run along each side of the boiler for its full length. These water legs are connected near the center by an 18-in.-diameter circulating cross-drum, which serves also as a bridgewall. This drum has an 8-in.-diameter vertical connection to the boiler shell and two 6-in.-diameter horizontal connections to the wet-back at the rear of the combustion chamber, as indicated in Fig. 1.

The failure was in the circulating cross-drum of the forward boiler. Leakage in this drum had become evident and repair men from a local boiler shop were called in to weld the leak before the boat left Pawtucket on the morning of the accident. The welders reported a crack about 7 in. long near the longitudinal seam, which

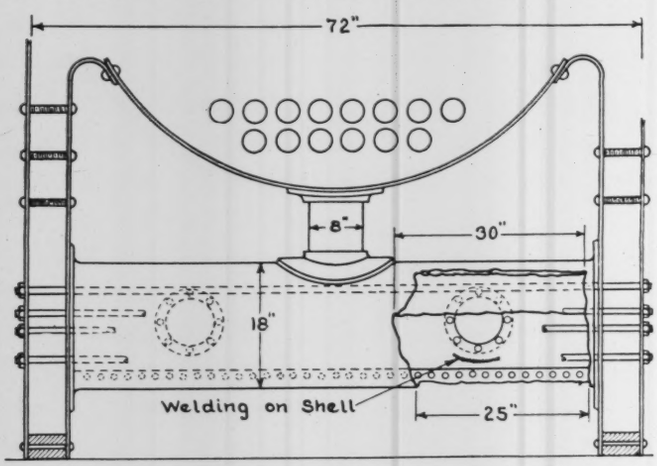


FIG. 1 SECTION OF "MACKINAC" BOILER SHOWING WELDING ON SHELL

they were unable to repair because of lack of room and too much moisture from the leak; so that the boat set out for Newport forty-five minutes late and with only the aft boiler, which had not been giving trouble, under steam. A fire was later started under the forward boiler and the return trip begun about 5:30 p.m. with both of them in operation at reduced pressure. When but a short distance out from Newport the circulating cross-drum of the forward boiler failed. The rupture began at a line about 25 in. long parallel and very close to the longitudinal seam—which was near the bottom of the drum on the side away from the grates—and tore a strip of this width circumferentially around more than one-quarter of the drum. The nature of the failure is clearly shown in Figs. 1 and 2. The piece marked "B" in Fig. 2 is the torn part of the drum shell. The piece marked "A" had no connection with the boiler.

Most of the killed and injured were on the main, or freight, deck, where dancing was in progress, and were immediately enshrouded with live steam. The absence of a non-return valve on the steam line permitted the other boiler to continue to empty itself through the rupture. Although no parts of the boiler were violently projected about the boat, the pressure attained in the boiler room was sufficient to raise the steel main deck about 12 in. The reaction of the escaping jet moved the boiler forward about one foot. The steam pressure allowed was 142 lb., although only about 100 lb. was being carried at the time of the accident.

The cause of the failure was external corrosion, the wasting away of the outside surface of the boiler. Both of the boilers on this vessel were inspected in April, 1925, by the Government Steamboat Inspection Service. The January, 1926, issue of *The Locomotive*, published by the Hartford Steam Boiler and Insurance Co., from which the foregoing information has been obtained, states that it is hard to believe that any one at all familiar with boiler construction would even consider repairing a boiler that had wasted away over a large area to the extent that there was an actual opening more or less continuous for a distance of approximately 7 in. Yet the welders called in on the morning of the accident attempted to weld this opening, and would have done so had conditions permitted.

A still further indication that the generally corroded condition

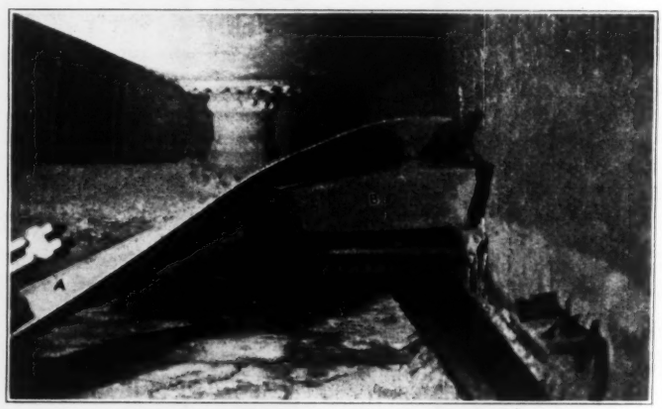


FIG. 2 SECTION OF "MACKINAC" BOILER SHOWING TORN PART OF THE DRUM SHELL

of certain parts of the boiler had become evident is given by the fact that on the 5-in.-diameter pipes connecting the ruptured drum with the wet-back, 75 per cent of their external surfaces had been welded over.

April, 1926, Meeting of the International Electrotechnical Commission

IN CONNECTION with the Louisiana Purchase Exposition held in St. Louis in 1904, there was held a series of sessions of the International Electrical Congress, participated in by representatives of many countries, for the discussion of standardization in the electrical field. Out of this grew the most comprehensive organization for this purpose now in existence, the International Electrotechnical Commission. This body was organized in London, England, in 1906, by a group of engineers and scientists representing technical societies and governments of more than a dozen countries.

This meeting drew up plans for a definite organization, and established rules of procedure and a form of organization that has stood the test of time, and is still actively working in substantially its original form. Lord Kelvin was the first president of the Commission, and the original secretarial organization, under the direction of Mr. Charles Le Maistre, of London, is still functioning.

The scope of the work of the Commission was initially confined to strictly technical details of electrical engineering, such as the definition of terms and the encouragement of efforts to establish international definitions of basic units, such as the ohm and the ampere. As time went on, the Commission has attacked broader questions, and is now studying such questions as the rating and testing of apparatus, not only in the electrical field, but also in the field of prime movers for electric plants. In July, 1914, the Commission published specifications on the nomenclature of hydraulic turbines, and this document is now under revision as part of a more comprehensive scheme which calls for the preparation of specifications for the nomenclature, rating, and testing of not only hydraulic turbines, but also of steam turbines and of internal-combustion engines, as applied to the driving of electrical machinery.

The Commission works through national committees in each

of the twenty-four participating nations, with advisory committees supervising its activities along various lines. The Commission has held meetings approximately annually, save for an interruption during the war, and at these meetings official delegates discuss the findings of the various constituent bodies, and recommend projects for adoption by the Commission.

The next meeting of the Commission is to be held under the presidency of M. Guido Semenza, of Italy, in New York in April, 1926, and it is expected that upward of 125 delegates will attend. Elaborate plans are being made to promote the success of the meeting, including a conference of delegates of national standardizing bodies arranged for by the A.E.S.C.

A tour of the northeastern part of the country is planned for the delegates.

The details of the program of the I.E.C. meeting are not yet complete, but among the topics to be considered are the rating of electrical machinery with respect to capacity, test voltages, and the like; the revision of the hydraulic-turbine specifications and the preparation of similar documents for steam turbines and internal-combustion engines; the continuation of the task of preparing an international glossary of electrical terms, of safety-code rules for overhead lines, and a number of other important items. Further details will be made public as the program becomes more definite.

Extensive Research on Boiler Feedwater Now in Progress

IN MAY, 1924, the Standardization Council of the American Water Works Association approved a program to carry on a study of the treatment of water for use in steam boilers. The studies are to include the causes and prevention of corrosion of ferrous and non-ferrous materials used in steam-station practice, and other problems in railroad and central-station practice. The work is being done jointly with the National Electric Light Association, American Railway Engineering Association, and The American Society of Mechanical Engineers.

The study is being carried on by ten committees, an advisory committee and nine sub-committees. Each sub-committee is collecting data relative to the subject assigned to it and will compile a yearly report. The reports of the various committees, after review by the advisory committee, will be passed for publication. All reports passed by the advisory committee will be published in one or more of the journals of the technical societies participating in this study.

The Advisory and Editing Committee, of which S. T. Powell, Chemical Engineer, Baltimore, Md., is Chairman, consists of the following:

A. J. AUTHENREITH, Middle West Utilities Co., Chicago, Ill.
EDWARD BARTOW, University of Iowa, Iowa City, Iowa.
J. H. BUELL, Oklahoma Power Company, Tulsa, Okla.
A. G. CHRISTIE, Johns Hopkins University, Baltimore, Md.
WELLINGTON DONALDSON, Fuller and McClintock, New York, N. Y.
V. M. FROST, The Public Service Electric and Gas Co., Newark, N. J.
C. P. VAN GUNDY, Baltimore & Ohio R.R., Baltimore, Md.
C. F. HIRSHFELD, Detroit Edison Co., Detroit, Mich.
A. L. PENNIMAN, JR., Con. Gas Elec. Lt. & Pr. Co., Baltimore, Md.
GEORGE C. WHIPPLE (deceased), Harvard University, Cambridge, Mass.

This Committee is to direct the work of the sub-committees, to review and edit all reports and papers submitted for publication, and to determine where and when the material shall be printed. The chairmen of all sub-committees will serve as ex-officio members of the Advisory and Editing Committee.

Sub-Committee No. 1. Sedimentation with and without chemicals, pressure and gravity filters and deconcentrators, continuous blow-down apparatus. A study of these methods applicable to steam station and railroad practice, R. C. Bardwell, Supt. Water Service, C. & O. R.R., Richmond, Va., Chairman.

The general outline of work of the committee is as follows:

1 The value of sedimentation from a practical viewpoint, as a complete treatment, or when used in conjunction with filters. The committee is to determine the relative efficiency of continuous-flow-type basins or tanks in comparison with sedimentation basins operated on the fill-and-draw plan.

2 The committee should attempt to establish the relative value of pressure and gravity filters for the removal of suspended solids, and make recommendations as to rates of flow through filtering material, as applied to industrial treatment. It is to determine also the kind and size of filtering materials best adapted to such work, and other pertinent information which may result in a clearer understanding of the functioning of these appliances.

3 Deconcentration and continuous blowdown methods are being applied in steam-station practice in this country and abroad. Much valuable information may be collected by the committee with respect to these apparatus. Special study is to be given to the theory of the operation of appliances of this kind to determine their value in comparison with other processes in the removal of scale-forming constituents from boiler water.

4 There is little information on the use of coagulants and their effect in steam-station operation, based upon actual operating experience in this field. Pioneer work is possible and desirable.

Sub-Committee No. 2. Water softened by chemicals (external treatment), C. R. Knowles, Illinois Central R. R., Chicago, Ill., Chairman.

The following items are being considered by the committee:

1 The chemical reactions in the light of present knowledge of physical chemistry, with special attention to the hydrogen-ion concentration of water and its influence upon the precipitation of hardening salts.

2 Compilation of operating data to determine the relative value of continuous and intermittent softeners.

3 Collection of operating figures showing the efficiency of subsidence tanks and basins in order to be able to submit recommendations for the more efficient design of basins for precipitation of solids, and the removal of sludge.

4 The causes and prevention of retarded chemical reaction.

5 Standardization of rates of filtration employed for the removal of suspended solids from softened water.

6 The effect of silicious material as a filtering medium when used in conjunction with hot chemical softeners, and the value of non-silicious filtering material.

7 A consideration of the economic value of lime-soda softening preliminary to zeolite softeners or to evaporators.

8 Standardization of nomenclature in the field of softening of water by chemicals and of the apparatuses and appurtenances in use.

Sub-Committee No. 3. Zeolite softeners, internal treatment, priming and foaming, electrolytic scale prevention, Alfred H. White, Director of Engineering, University of Michigan, Ann Arbor, Mich., Chairman.

The adaptability of zeolite softeners and boiler compounds to the treatment of water has not been well defined. The committee is to standardize the nomenclature used with these processes, determine the physical and chemical principles upon which the processes function, and allocate them to their specific spheres of usefulness in railroad and stationary steam practice.

There has also been assigned to this committee the study of electrolytic processes for the prevention of scale formation and the causes and prevention of priming and foaming. Pioneer work in connection with a study of the electrolytic methods of scale prevention will be necessary, since the use of this method of treatment of boiler waters, at least in this country, is comparatively recent.

Sub-Committee No. 4. Surface condensers, evaporators and deaerators, A. E. White, University of Michigan, Ann Arbor, Mich., Chairman.

This committee is to prepare for publication current information and data pertaining to the operation of these apparatus and to designate their individual uses in steam stations. The committee

will give consideration to economic possibilities of the use of lime-soda and zeolite softeners as an adjunct to evaporators and deaerators.

The committee is to study the causes of dezincification and corrosion of condenser tubing, the value of the Cumberland process (an electrolytic method) for the elimination of deposit on condenser tubes, and the deaeration of water by iron and the applicability of the process to steam stations.

Sub-Committee No. 5. Corrosion of boilers and the effect of treated water in accelerating or relieving these troubles.

The removal of dissolved gases from feedwater has done much to eliminate corrosion. There is little knowledge available, however, concerning the causes of corrosion in boilers and superheaters using water that has been practically deaerated. Paul has indicated the possibility of production of organic acids under the influence of the high pressures and temperatures in boilers. He points to certain conditions where formic acid has been produced from sodium carbonate with the production of free oxygen. Little, if any, work has been done in this country with respect to these conditions. With increasing tendencies toward higher temperatures and pressure in boilers, studies along these lines are desirable.

The corrosion and dezincification of condenser tubes has caused great financial loss, especially along the Atlantic Seaboard. There is a need for research in this field, since great financial losses are incurred yearly because of these replacements. The committee is to review in its early studies the proceedings of the Institute of Metals of Great Britain, where so much investigative work has been done in recent years, and is compiling operation data from a number of stations where troubles of the kind are being experienced.

Sub-Committee No. 6. Embrittlement of metals, A. G. Christie, Professor of Mechanical Engineering, Johns Hopkins University, Baltimore, Md., Chairman.

Recent study of the embrittlement of metal indicates that the contributing agent is high concentration of caustic soda in boiler waters, in the absence of other salts, principally chlorides and sulphates. There are some, however, who believe that the crystallization of boiler metal is caused by strains set up in the metal during operation. Studies by a number of investigators are in progress at the present time, and interesting data concerning the cause and prevention of this phenomenon are expected in the near future. This committee has collected some data on the subject, and may further the progress of the work by the inauguration of studies at universities equipped for work of this kind.

Sub-Committee No. 7. Municipal water supply in relation to boiler use, V. Bernard Siems, Water Engineer, Baltimore, Md., Chairman.

The primary function of this committee is the collection of data relative to the quality of water for steam-making uses, supplied by municipalities, leading toward more intelligent control of public water supply in respect to this class of consumer. The second duty of the committee is a study of trade-waste pollution of surface waters, in so far as such pollution is detrimental to the operation of industrial water-treatment plants or surface condensers.

Sub-Committee No. 8. Standardization of water analysis, H. Farmer, Philadelphia Elec. Co., Philadelphia, Pa., Chairman.

This committee has collected much valuable data, indicating that the study is well worth while.

Sub-Committee No. 9. Bibliography, P. W. Swain, Assoc. Editor, *Power*, New York City, Chairman.

The compilation of a complete bibliography of boiler-feedwater methods and allied problems is an undertaking of such magnitude that it may not be feasible at this time. The publication, at intervals, of current developments in this field, however, is an effective way of transmitting to plant operators information on progress in the industry. Much of this material is in the technical press which now reaches plant managers and operators. The committee is to abstract current articles of interest and these will be published at regular intervals in the following periodicals: *Power*, MECHANICAL ENGINEERING, Journal of the American Water Works Association, Prime Movers Committee Report of the National Electric Light Association, and possibly other journals of the societies affiliated in the study. These abstracts will begin to appear within the next few weeks.

Major Max Toltz Fund for Assistance to Students

MAJOR Max Toltz, Mem. A.S.M.E., of St. Paul, Minn., has given $15,000 to The American Society of Mechanical Engineers to establish a fund for the assistance of students in engineering. The splendid spirit of the gift and the purpose for which it is to be used are best understood from the letter of gift.

NEW YORK, December 2, 1925

TO THE COUNCIL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS:

I hereby give to The American Society of Mechanical Engineers the sum of $15,000 to be used for the assistance of students of engineering in the process of their education.

I would prefer to have only the income expended for the assistance of students of mechanical engineering who are nearest to the completion of their college courses; hoping also that means will be provided by which students who are assisted will gladly repay to the Society any sum advanced to them in order that in the future other students may be assisted more effectively. I suggest that the sons of our members have first consideration.

Let me say that this gift is thus made without rigid specification having full confidence that the Council and the Committees through which they administer this fund will use the money in the spirit with which I am giving it to the end that the greatest number of worthy students may be enabled to complete their education for the profession that we all love.

MAX TOLTZ.

At the meeting of the Council on December 4, 1925, this gift was accepted and the Committee on Awards, of which Dr. Ira N. Hollis is chairman, was asked to state a procedure under which the Fund should be administered. On January 13, 1926, at its Washington meeting, the Council received and adopted the procedure presented by Dr. Hollis which follows:

1 That the gift of $15,000 (fifteen thousand dollars) by Major Max Toltz, a member of this Society, be known as the Major Max Toltz Fund for Assistance to Students.
2 That the full amount be invested by the Treasurer and the Finance Committee, to be kept intact, and that the income be used to restore the fund to $15,000 in case any losses occur.
3 That under ordinary circumstances only the income be used.
4 That in cases of exceptional need where money is not available from income of the Fund, small amounts may be advanced by the Society, under guarantee of this special Fund and its income.
5 That for the present the assistance to students be in the form of loans, at five per cent interest, commencing from the date the money is advanced.
6 That loans be made through the Committee on Awards, only to students approved by a responsible officer of the institution to which they belong.
7 That further necessary regulations for the use of the income to assist students be made by the Committee on Awards as that income becomes available and that all rules and cases be reported to the Council.

In discussing the Fund, Dr. Hollis said: "It is difficult to realize how large a gift like that of Major Toltz may become in the course of time, provided the original amount is kept as a fund invested in good securities. If the income loaned every year to students is returned, the amount available for further loans is rapidly compounded. For instance, the first year beginning next fall the Fund will have about $750 which can be loaned. The second and third years there will be similar amounts. But if the loan for the first year is to be paid back in the fourth year then there will be $1500 for loan that year. We hope that the Society may last a long time. If it does last 100 years, the amount available from the original gift will yield about $75,000 per year for benevolent purposes. No one can estimate at the present time how much this may do for those who are struggling for an education, and untold hundreds may find their hearts filled with gratitude to Major Toltz for his generous thoughtfulness to American youth.

"The success of the Fund will depend not only upon the faithfulness of the administering but still further upon the helpfulness of college officials, upon whom recommendations will depend because the Society has no means of knowing individual students in the distant parts of the country. At first, few can be helped. In the course of 20 years many will find assistance. Consequently, we have reason to rejoice at this start of an admirable fund."

Federal Oil-Conservation Board Meets

THE Federal Oil-Conservation Board was organized on December 19, 1924, by President Coolidge to study the Government's responsibilities and to enlist the full coöperation of representatives of the oil industry. The Board consists of the Secretaries of War, Navy, Interior, and Commerce, and works in coöperation with a special commission appointed by the President in March, 1924, to study the best policy to insure the future supply of fuel oil for the Navy.

The Board held an open-forum discussion of the subject in Washington on February 10–11, primarily to find out what the oil industry thinks about the problem of conservation of oil and what suggestions it can make.

The oil industry responded to the Government's invitation in no uncertain terms. If there was anything in the meeting about which extremely little doubt was left, it is that the oil industry does not want any oil conservation established by legislative means. Through its most prominent spokesmen, such as W. C. Teagle, president of the Standard Oil Co. of New Jersey, E. W. Marland, Marland Oil Co., J. Edgar Pew, vice-president of the Sun Oil Co., and others, the oil industry denied that there is any need for special means to insure oil conservation and vigorously affirmed that if left to themselves the economic laws of supply and demand will insure the American public a plentiful supply of oil at low prices for a long time to come.

The only representative of important interests who took the opposite view was Henry L. Doherty, of New York City, but it was plainly shown by a number of speakers in the open forum that his views were not shared by other representative interests of the industry.

The conference brought out certain facts of great interest. As far as production of oil goes, practically all the speakers were agreed that the present system of extraction of oil from the ground by flowage and drainage is imperfect and not more than 10 to 25 per cent of the oil in the ground is actually recovered. Some reports were made on work done by H. L. Doherty and James O. Lewis toward a better extraction of oil by artificial pressure after the natural pressure had been relieved by the outflow of gases. The Doherty research on the influence of viscosity of oil on its retention by the sands and sandstone formations of the beds was repeatedly referred to.

The present handling of pools evoked practically unanimous criticism. The legal status of oil until quite recently was essentially that of wild game. He who captures it first has it. A man drilling a well can not only extract the oil beneath his own land but also that beneath his neighbor's, and his neighbor has no legal redress. As soon as the first discovery well establishes the presence of oil in commercial quantities, every owner of an adjoining plot who can afford it starts a well or wells of his own with the idea of taking out oil before his neighbor has the chance to take it away. The results are usually anything but fortunate. In many instances the pool proves to be a flash in the pan, entirely incapable of supporting the number of wells that are sunk. In other instances, an excessively large number of dry holes are put into the ground. Earl Oliver, a consulting engineer of Ponca City, Oklahoma, cited two fields, in one of which there was an agreement between owners restricting the number of wells put down, and in another indiscriminate competitive well drilling was engaged in. In the first of these fields $2^1/_2$ wells were sunk to each producing well; in the second, 14 wells to one producing well. Whether such indiscriminate and wasteful well drilling means the loss of oil or the loss of money, it represents a serious waste, particularly nowadays when deeper wells are drilled and $60,000 is none too much to put a well down in the ground.

When it came, however, to the question of how such a situation can be regulated except in the few cases where voluntary agreement can be had, it was obvious that the industry has not yet found a legitimate method. Constitutional and legal grounds apparently stand in the way of legislation (advocated by Henry L. Doherty, and a milder form by R. H. Smith of the Oklahoma Oil Co., Philadelphia, Pa.) enforcing unit pool operation, desirable as it appears. And one of the speakers not without grim humor remarked that voluntary agreements might result in the parties to these agreements being sent to jail under the Sherman-Clayton law.

The general impression left by the conference was that the advocates of conservation by legislative coercion are to be found mainly outside of the oil industry. The main arguments for conservation and answers to them given by the representatives of the oil industry will be summed up in the following paragraphs. The most important argument for oil conservation is the threatened exhaustion of oil resources, particularly its bearing on national defense. Advocates of conservation state that so enormous has been the consumption of oil that the country is relying for its supplies in the very near future not upon proved deposits but upon the chance of discovery of new deposits, and they ask what would happen if when the country was at war no new deposits were discovered.

The oil industry replies to this that what between oil in storage above ground and known deposits underground, the country at the present rate of consumption has a guaranteed supply of oil for between five and ten years. Should there be a danger of war and consequent possibilities of intensified demand for oil, a more vigorous search for new deposits would be made and unquestionably many found. In this connection J. Edgar Pew quoted U. S. Geological Survey predictions which declared officially in 1900 that Pennsylvania and New York would undoubtedly continue to be the main sources of supply of oil and that Illinois and Texas need not be seriously considered in this connection. At that time the production of oil was, however, only 63,000,000 bbl. As late as 1909 the U. S. Geological Survey estimated the future recovery of oil from Texas and Louisiana as 200,000,000 bbl. Since 1909 these states have produced more than 1,300,000,000 bbl. and are still producing.

The unprecedented growth of the use of automobiles, say conservationists, is making such demands on the oil industry as to cause a rapid exhaustion of available supplies. Statistics are cited showing that consumption of oil trebled every ten years since the first discovery of it in 1859. In answer to this representatives of the oil industry point to great achievements attained by the use of cracking processes. The early oil industry had practically only one product to sell, and that was kerosene. Today the controlling product is gasoline. Until comparatively lately gasoline could be produced only out of crude oil, and to a certain extent out of casing-head gas. Of late, however, the development of cracking has been carried to such a point that, if desired, every gallon of fuel oil can be converted into gasoline. In this way, to all practical purposes, an enormous additional source of raw material has been given to the gasoline industry. Not only that, but very rapidly the problem is being solved of successfully cracking oils which until quite lately have not been considered suitable for this purpose at all. Thus W. C. Teagle, of the Standard Oil Co. of New Jersey, stated that within the last year more than 1,000,000 bbl. of California oil were brought East and successfully submitted to cracking treatment.

Something must be done, say advocates of conservation, about oil consumption in lines where coal can be used just as well. The supplies of oil are limited, while supplies of soft coal are to all practical purposes unlimited. Why use a material in which a shortage is impending when another material of which there is a superabundance is available? Here again the oil industry does not agree with those who would impose salvation upon it. Statistics have been cited showing that probably not more than 100,000,000 bbl. a year are burned where some other fuel could be technically used. They point out, however, that there is a great difference between technical availability of coal and its economic availability. The Pacific Coast industries depend on liquid fuel, because good coal at possible prices is not available. The same for various reasons applies to other uses of oil where it comes into competition with coal, the result of the analysis of the situation being that probably not more than 20,000,000 to 25,000,00 bbl. of oil can be actually replaced by solid fuel without material loss or disadvantage to the consumers, and even this would involve expensive measures of legislation and supervision. Twenty-five million barrels of oil is less than two weeks' production of the 300,000 wells operating within the United States, and is too small to have a material effect.

Chicago Holds Successful Power Conference

Six Engineering Groups Coöperate in Four-Day Meeting Featuring Twenty Papers by Outstanding Engineers Which Elicited Splendid Discussion—Interesting Exhibition Held Simultaneously Draws Large Crowd

APPROXIMATELY 1200 engineers, mostly from the Middle West, registered at the Midwest Power Conference held at the Furniture Mart Building, Chicago, from January 26 through 29, 1926. This meeting, which was a magnificent success, was the outcome of the coöperation of the Western Society of Engineers, the National Safety Council, the Great Lakes Section of the National Electric Light Association and the Chicago Sections of the American Society of Mining and Metallurgical Engineers, the American Institute of Electrical Engineers and the American Society of Mechanical Engineers.

An interesting exhibition of power equipment was held at the same time in the same building. About 50,000 visited the show which was characterized by its broad appeal and the splendid arrangement of the building, permitting an excellent showing of the various types of equipment. About 200 exhibitors were represented, covering every phase of modern power-plant development.

One of the interesting features of the Conference was the dinner on Thursday evening January 28th at which Charles Piez presided. The speakers of the evening were J. A. Emery who emphasized the advantage which plentiful and readily available power is giving to Americans of the present, and General Charles Keller, who told of the wartime problem of apportioning power to the essential industries.

Five sessions were held and the presiding officers were W. L. Abbott, Chicago, Ill., President of The American Society of Mechanical Engineers, B. F. Lyons, Chicago, Ill., President of the Great Lakes Section of the National Electric Light Association, Homer Niesz, Chicago, Ill., President of the Western Society of Engineers, James H. Herron, Cleveland, Ohio, and Dean A. A. Potter of the Department of Engineering, Purdue University, Lafayette, Ind.

The addresses and papers at the Conference included the following: Some Comments on the Power Developments of the Mississippi Valley, by Samuel Insull, Chicago, Ill. (Abstracted in this account of the Conference.) Power Resources of the United States, by Daniel W. Mead, Madison, Wis. (To appear in abstract in a later issue of MECHANICAL ENGINEERING.) Changing Viewpoints in Hydraulic-Turbine Practice, by H. Birchard Taylor, Philadelphia, Pa. (To appear in abstract in a later issue of MECHANICAL ENGINEERING.) Suggestions Regarding Hydraulic Plant Operation, by L. F. Harza, Chicago, Ill. (To appear in abstract in a later issue of MECHANICAL ENGINEERING.) Extension of Electric Service to Rural Communities, by G. C. Neff, Madison, Wis. Electric Power Development in the Chicago District, by William S. Monroe, Chicago, Ill. (Abstracted in this account of the Conference.) Present Practice in the Burning of Pulverized Fuel, by C. F. Hirshfeld, Detroit, Mich. (Abstracted in this account of the Conference, accompanied by a discussion by E. H. Tenney of St. Louis, Mo.) By-Product Processing of Coal, by H. W. Brooks, Fullerton, Pa. (An article in this issue.) Boiler-Water Conditioning, by R. E. Hall, Pittsburgh, Pa. (To appear in a later issue of MECHANICAL ENGINEERING.) Layout and Equipment of Industrial Power Plants, by Paul L. Battey, Chicago, Ill. (Abstracted in this account of the Conference.) A Machine for Testing Steam-Turbine Nozzles by the Reaction Method, by G. B. Warren and J. H. Keenan, Schenectady, N. Y. (An article in this issue.) Safety and First Aid in Industrial Plants, by C. B. Scott, Chicago, Ill. Purchased Power for Coal Mines in Illinois, by J. Paul Clayton, Springfield, Ill. The Diesel Engine in the Industries, by Max Rotter, St. Louis, Mo. The Diesel-Electric Locomotive, by Samuel M. Vauclain, Philadelphia, Pa. (To appear in a later issue of MECHANICAL ENGINEERING.) The Economics of Oil as a Boiler Fuel, by Allen F. Brewer, New York, N. Y. Gas in Industry, by H. H. Clark, Chicago, Ill. (Abstracted in this account of the Conference.)

Present Practice in Burning Pulverized Fuel

By C. F. HIRSHFELD,[1] DETROIT, MICH.

PULVERIZED-fuel firing was used successfully in other industries before it was adopted in power plants for the generation of steam. It failed for this purpose at first. There were troubles with slag, with the melting down of refractory walls, with the plastering of fused ash on boiler surfaces, and the like. In the light of present knowledge it is clear why this happened. The early experimenters were working with comparatively small furnaces and using methods which resulted in violent combustion. They were therefore dealing with a comparatively short and very hot flame without taking the necessary precautions for handling it.

The promise of success came when it was experimentally discovered that powdered fuel could be burned with a fair degree of success under a steam boiler provided one would use a sufficiently large furnace and a slow enough rate of combustion. The first really successful installations used large furnaces and what has been termed "streamline combustion," that is, combustion in which the mixture of fuel and air took place slowly along the rather great length of the stream of fuel and air as it actually flowed through the furnace. This did not eliminate all the troubles, but started a rather tremendous activity in the development of new methods and new ideas. The first of these was the development of cooled walls, either air-cooled or, at a later day, water-cooled. These served to remove certain limitations in the use of pulverized fuel and permitted considering the possibility of reducing the furnace size and hence investment, a factor to which the author attaches great importance.

The industry is now in the midst of a series of experiments, some on a laboratory scale and some on a commercial-plant scale, in the use of more rapid methods of burning the fuel, which should result in ability to use smaller furnaces. One method which is being tried in several different ways depends upon the rather intimate mixture of air and fuel just outside of the furnace, as it enters the furnace, or just after entrance, the mixture being effected by the feeding device, or feeding and burning device combined.

An entirely different method, which is by some, at least, supposed to be more promising, consists in introducing what one might call opposing or partly opposing streams of fuel and air, so that the agitation occurs through the formation of a vortex or whirlpool inside the furnace. The author personally believes that ultimately we must come to the use of violent agitation in some way and a short flame.

The author has just completed a rather elaborate study based on actual operating costs in both stoker-fired plants and pulverized-fuel-fired plants. He found that at the present time the cost of producing steam from high grades of Western bituminous coal is practically the same in both methods (disregarding a number of intangible values). As coal becomes poorer in quality the advantage of burning in pulverized form, when measuring cost of steam in dollars and cents, becomes greater.

Pulverized coal has a greater flexibility in the sense that it is less affected by the character of the coal. Also it is more flexible than stoker firing in the sense that the latter may be high at high rating or high at low rating, but it cannot be high at both. With powdered fuel properly used, the efficiency curve can be maintained reasonably flat.

While, however, a pulverized-coal plant can burn a wide variety of coals and yet get out the steam, it does not mean necessarily that it will secure the best results with the poorest grades of coal.

[1] Ch. Research Dept., Detroit Edison Co. Mem. A.S.M.E.

It may in the end be found that it pays best to use a good grade of coal.

The success of pulverized-coal does not mean, in the opinion of the author, that the stoker is doomed. On the contrary he believes that stokers will be used for many years to come, and that in the near future stokers will become available in such improved types as to challenge again the supremacy of pulverized coal. Pulverized coal is not a universal cure. When properly adapted it will serve to solve a great many of our difficult problems. It will not solve all of them, at least not unless we tackle the problem of its use as engineers with the dollars-and-cents' point of view and with nature's laws in mind, and not necessarily as the powdered-fuel-equipment salesman tells us.

Powdered Coal for Ashley Street Station

BY W. H. TENNEY,[2] ST. LOUIS, MO.

FURNACE changes at Ashley Street Station, St. Louis, Mo., were undertaken early in 1925 for the purpose of increasing boiler capacity and eliminating smoke. This was to be effected by larger water-cooled furnaces fired with powdered coal. The unit type of pulverizer was chosen largely because the physical arrangement already operating was not suited to the application of a central pulverizing system. It was found in the test installation that a furnace volume of approximately 3200 cu. ft. was required. This is 5.75 cu. ft. per rated boiler hp. It was also determined in this test installation that a certain speed and turbulence of the fuel and air must be set up by the burner if early ignition and complete combustion of the fuel were to be effected within this space. Straight shot burners resulted in late ignition and erosion of the rear furnace wall. A burner is therefore used which supplies with the coal from 50 to 80 per cent of the air required for combustion, the remaining 50 to 20 per cent of secondary air being admitted through deflection vanes which surround the incoming-fuel nozzle. This secondary air supplies the necessary turbulence immediately in front of the burner.

In view of the previous unsatisfactory experience at Cahokia Station with air-cooled walls, it was decided to install water-cooled walls in the Ashley Street furnaces, which would permit of sustained high rates of combustion without the damage experienced on brick walls. This, it was decided, could be most effectively accomplished by the use of the refractory-faced blocks developed by the Bailey Meter Co., this construction making it possible to do away entirely with all the brickwork in the boiler and furnace setting with the exception of the front and rear walls of the furnace. Bare cast-iron blocks were used on the lower section of the furnace to prevent possibility of slag formations. With this construction it is possible to operate at rates in excess of 300 per cent continuously without formation of molten slag in the furnace and without injury to the furnace walls. The Ashley Street Station has eight of these furnaces installed and in operation.

Many interesting problems had to be solved in the installation of these furnaces. Particular mention is made of the burners. On the first furnace three burners were installed, one at the bottom of the furnace and two above. It was found that the lower burner did not permit the fuel from the upper burners to sweep down through the furnace sufficiently for complete combustion; as a result the bottom burner is now omitted. The use of two burners at the upper location proved to be entirely satisfactory, especially when they were tilted down 20 deg. from the horizontal. The velocity of fuel and air leaving the burners had also to be worked out with relation to the width and length of the furnace and in relation to the necessary turbulence of the flame. It was found that too great a turbulence resulted in losses but of a different nature than those experienced with the straight shot burner.

Adjustments of the cone spreader at the end of the coal feed pipe had to be made, also with reference to the velocity and spread of fuel, and in relation to the percentage and velocity of secondary induced. Secondary air was put through the burners under pressure, but in the light of results obtained this was not necessary.

With water-cooled walls there was a reduction of about 60 per cent in the temperature of steam leaving the boiler. Because of this the convection-type superheaters were supplemented with radiant superheaters located in the rear wall of the furnace, thereby bringing the superheat to the desired 150 deg. The performance of these powdered-coal furnaces has for the most part met all expectations. The 70 per cent boiler and economizer efficiency previously obtained has now become 83 per cent and the maximum former 200 per cent of rating has become 325 per cent. With the very low grade of coal utilized in the St. Louis plants the ease and economy of operation with which furnaces are now run as compared with the many difficult and wasteful conditions previously experienced even at low ratings, are of such an extent as to be worthy of special attention.

[2] Ch. Engr. Power Plant, Union Elec. Light & Power Co. Mem. A.S.M.E.

Gas in Industry

BY H. H. CLARK,[3] CHICAGO, ILL.

THE gas and electric industries must work together, as both of them depend almost wholly on coal as a source of energy for their product and sell their respective products in practically the same market.

In search for an outlet for current that would make the station load more uniform, the electric man is apt to consider electric-heating business. This, however, is not a business that has a permanent foundation under it. The investment necessary to produce and deliver electrically a certain amount of useful heat to the customer is three times as great as when done by gas. To deliver the same amount of useful heat to the customer, an electric station consumes four times as much coal as the gas station.

Under these conditions power-plant builders should be careful in planning for the future, because while some successful heating apparatus has been installed, it has been a virgin field, and, in the opinion of the author, will some day be lost to other fuel. For light, on the other hand, one pound of coal burned under the boiler of an electric power plant will deliver 20 per cent more candlepower of useful light for the customer than the same pound of coal put through a modern by-product gas plant.

The latter will play an increasingly important part of the economics of the nation. Liquid fuel of the future will come from coal. The by-product gas plant is the logical place to produce it, and men trained in the gas industry are best suited to operate the plants. The author believes even that in designing future electric power plants engineers should take into consideration the possibility and advisability of by-product recovery from coal and the use of coke or gas as fuel under boilers, or gas as fuel for gas engines or gas turbines to drive electric generators.

Gas as fuel under steam boilers may have advantages not known at this time. Some experiments should be made to determine the relative effect on boiler shells and tubes of the intense radiant heat produced by coal, and the soft, blue-flame, bunsen-burner effect of gas fuel. Does the liberation of so much radiant heat on a small grate area have a more serious effect on the boiler than liberating the same amount of heat over a much larger area?

[3] Industrial Gas Engr., Peoples Gas Light & Coke Co.

Layout and Equipment of Industrial Power Plants

BY PAUL L. BATTEY,[4] CHICAGO, ILL.

THE author emphasizes that because of special conditions existing in many plants the design and equipment of an industrial power plant justifies a careful and comprehensive analysis of all of the broadly related factors. The most vital factor in the opinion of the author to be considered in the design of an industrial plant, including the power plant, is the "use factor." Mere technical or thermal efficiency in the plant represents only part of its real utility. The commercial or "investment efficiency" must also be considered, but both of these efficiencies are never fixed; they vary with the development of equipment and with the changes in price of both equipment and operating items, particularly fuel and labor, the raw materials of the industrial power plant. The

[4] President, Battey & Kipp, Inc. Mem. A.S.M.E.

author attempts to set out relative values in such a manner that the entire problem may be visualized and a better coördination or balance be reached. The variable factors cannot be balanced except on terms of current values, so that a good answer today may not necessarily be equally so tomorrow.

The author discusses in particular the cases where steam is used for processes and their purposes

The term "use factor" which the author employs above covers both that of load and diversity. The "use factor" reflects the economic aspect of investment, depreciation, taxes, insurance, and to a certain extent maintenance and labor, and these items represent from 50 to 55 per cent of the cost of electric power production while the fuel, operating labor, supplies and most maintenance constitute the remainder. Of the latter the fuel varies from 25 to 35 per cent of the total cost. With this in mind it is obvious that anything accomplishing, say, a 10 per cent increase in the use factor, will show twice the overall saving that 10 per cent reduction in fuel consumption affords.

Improvement in use factor generally centers around the coördination of the various plant service systems, taking advantage of all possible diversity of time of demand among them. While the industrial plant has not the degree of diversity found in commercial service, there is more opportunity to coördinate than is possible in public service. All services are subject to one management, instead of a number who have no interests in common. Some scheduling of factory operations is often possible which will help the power plant without upsetting production programs. Also it is frequently possible to increase the plant use factor by installation of storage reservoirs or tanks so that water may be pumped at off-peak periods or more continuously at reduced rates. Steam accumulators may be used for evening up the varying load from a number of units requiring process steam. Many instances are stated in illustration of this view.

Power Developments of the Mississippi Valley

BY SAMUEL INSULL,[5] CHICAGO, ILL.

AT THE first session (W. L. Abbott, President of The American Society of Mechanical Engineers, Chairman) Samuel Insull gave an address on the Power Developments in the Mississippi Valley. This territory includes in addition to the ten states actually bordering on the Mississippi River, the states of Michigan, Ohio, Indiana, Alabama, Kansas, Oklahoma, and Texas, and covers an area equal to thirty-eight per cent of the total area of the United States. Its wealth in 1922 was estimated at forty-three per cent of the total wealth of the United States. Included in the Mississippi Valley is one of the largest, most available, and most valuable coal deposits in the world, in addition to which this region produced fifty-three per cent of the oil of the total United States production.

The power development of the region, excluding the power in use on the farms and by the steam railroads, represents about thirty-seven per cent of the total power operated electrically in the United States. From this the speaker traced the history of development of central station power in the Mississippi Valley, beginning with the first central station erected in the fall of 1882 at Appleton, Wisconsin. The author has appropriately illustrated the development of the central-station business by quotations from his own speeches over a period of some thirty years. He long ago visualized that the solution of the problem of supplying the public and industries with electric power lay in centralized power generation, but the early state of electrical engineering was not encouraging and he did not gain full confidence in his views until a later date when the successful introduction of alternating current with changes of methods of power generation at the station and a clearer understanding of the fundamental economics controlling the production and distribution of energy and the sale of that energy showed with growing emphasis that he was right. By 1909 central stations were beginning to get results. They have seen the improvement in load factor, discovered the difference in diversity of demand between the industries; in short, learned their own business. By 1911 the idea began to take shape that not only within a community, but within a region including several communities, electric power generation should be centralized.

At the present time eighty-five per cent of the energy produced in the Mississippi Valley is interconnected. This is not done in one system. As a matter of fact there are fourteen very large systems, but they are very closely interconnected. The territory of the Mississippi Valley includes the longest transmission interconnection in the world. From the water powers of Central Wisconsin through the great load centers of the Chicago district, down by the mine-mouth plants of central Indiana and the Wabash River, and then through Southern Indiana to the Ohio River, tying in with the steam station and the water-power plant that is now being developed at Louisville, then on south seventy miles to a high-head storage water power of the Vicks River, and on through to the mine-mouth steam plants established in the high-grade coal fields of Virginia, there is a total of over seven hundred and thirty miles all connected up in one interest.

[5] Pres. Commonwealth Edison Co.

Electric Power Development in the Chicago District

BY WM. S. MONROE,[6] CHICAGO, ILL.

THE first central station in Chicago was built by the Chicago Edison Co. at 139 Adams St., now 120 W. Adams St., and put into operation in August, 1887. It had about 640 kw. capacity and a distribution system covering an area of several blocks of that immediate district. In 1894 was built the old Harrison Street Station. The transmission system from the Harrison Street Station for some years after it first went into operation was all by Edison three-wire system at 220 volts direct current. The low-tension distribution was, of course, a severe limitation of the area that could be reached from the power station. It was not until 1897 that the first application was made of high-tension three-phase alternating current. A rotary converter and step-up transformer were installed at Harrison Street with the three-phase alternating circuit at 2300 volts, interconnecting this station with another station at Wabash Avenue $3\frac{1}{2}$ miles away. The success of this experiment led to a similar station at Clark and Oak Streets, and within a few years the generating units of these stations were abandoned and the plants were operated as substations, receiving their power from Harrison Street.

A very great impetus was given to the central-station industry by the introduction of the steam turbine. Chicago has the distinction of building the first central station designed from the start for steam turbines. This is the now historic Fisk Street Station, the first turbine in which went into operation on October 2, 1903. It was a Curtis vertical-shaft steam turbine, built by the General Electric Company, and was by far the largest turbine unit up to that day. The generator was 25 cycles at 9000 volts and had a capacity of 5000 kw. With the building of the Fisk Street Station the generation of direct-current energy was entirely abandoned. Alternating-current high-voltage transmission had become definitely established, and vastly enlarged the area that could be served from a single power station.

The original development plan for the Fisk Street Station showed fourteen of the 5000-kw. units, a total of 70,000 kw. The first section of the building provided for four units. When the station was laid out in 1902, it was thought that the 70,000 kw. would take care of the Chicago requirements for ten years, but by 1911 that station contained ten vertical turbines of 12,000 kw. capacity each, the original four units having been taken out in 1909 and replaced by others of 12,000 kw., the Quarry Street Station had been built with six units of 14,000 kw., two of which had been built with six units of 14,000 kw., two of which were 60-cycle; the Northwest Station contained two 20,000-kw. 25-cycle units. This was a total of 244,000 kw. nine years after the Fisk Street Station was laid out. The eighteen vertical turbines in these three stations are all still in operation as reserve and peak-load units.

In the latter part of 1922 design was started on the Crawford

[6] Pres., Sargent & Lundy, Inc. Mem. A.S.M.E.

Avenue Station. In building this plant another attempt was made toward a distinct improvement in power-station efficiency by taking some more or less radical liberties with the steam cycle. A steam pressure of 550 lb. at the turbine throttle was adopted, nearly twice the highest pressure that had before been used in this country, and considerably higher than had ever been used except in experimental way. The steam temperature adopted was 725 deg. fahr., about 50 to 75 deg. higher than before. Compound turbines were used, and the exhaust from the high-pressure turbines was taken back to the boiler room and "reheated" in a separate "reheat-boiler" of special design. The turbines were designed for extracting steam from two or three stages for the purpose of heating the feedwater, a scheme which had been used to a limited degree before, and which contributes considerably toward improving the cycle efficiency, increases the available capacity of the turbine by taking work off the low-pressure wheels, and reduces the size of the condensers.

Another departure in this station is the use of vertical condensers standing up through the turbine-room floor instead of the usual horizontal ones, set underneath the turbine. This form of condenser was adopted largely on account of the very slimy quality of the circulating water from the Drainage Canal, it being the idea that the vertical tubes would keep clean for a longer period than the horizontal, and thus maintain a better average vacuum.

Analysis of the operating cycle of this plant indicated that even with the low-grade Illinois coal in use and given a good load condition for the turbines, a plant efficiency of $1^1/_2$ lb. of coal per kw-hr. should be obtained, equivalent to about 15,000 B.t.u. per kw-hr.

Three turbine units were ordered for this station as the first installation. One imported from C. A. Parsons & Company, Ltd., of England, 50,000 kw., another built by the General Electric Company of 60,000 kw. and the third by Westinghouse of 50,000 kw. A fourth unit is on order, a 75,000-kw. General Electric Company machine. The plant is not yet in full operation and will not be until the latter part of the year. There have been many difficulties encountered, and, for example, one of the turbines is running now at somewhat reduced capacity and efficiency because of some blade trouble which recently developed. These experiences, while similar to those likely to be encountered in starting any large new plant, were perhaps aggravated by the unusual character of much of the equipment, and the numerous details that were new and untried and had to be worked into operating condition. But in spite of these conditions, the operating efficiency has been fairly satisfactory. In the month of October the station had an output of 58,760 kw-hr. and an efficiency of 1.54 lb. coal per kw-hr., equivalent to 15,400 B.t.u. per kw-hr. (the coal averaging 9984 B.t.u. per lb.). When the three units are all finished, and with improved load conditions on the station, there is every indication that the efficiency originally estimated of 15,000 B.t.u. per kw-hr. will be obtained. This with the low-grade coal from central Illinois, so that with Eastern coal one should expect the Crawford Avenue Station to operate at between 14,000 and 14,500 B.t.u. per kw-hr. as against 15,000 to 15,500 with central Illinois coal. These figures apply to stoker firing.

There has been an enormous improvement in station efficiency in the Chicago district since the beginning of this century. From 1910 to 1920 the pounds of coal per kw-hr. were reduced from 2.98 to 2.47, and from 1920 to 1925 from 2.47 to 2.06. The average coal rate for the entire system was 3.0 lb. per kw-hr. in 1910. October, 1925, was the first month in which it went below 2.0 lb., and is it to be hoped will remain there. It is to be noted, however, that since the beginning of the World War the cost of fuel per unit of output has been far more dependent on the cost of coal than on the fuel efficiency of the station, and this no doubt will continue to be the case.

There are now five major power stations in the city of Chicago and several smaller ones, with a total capacity of 885,500 kw. The power stations are all interconnected by underground "tie lines" at the same voltages. These tie lines serve not only to stabilize the power supply throughout the city and to insure its reliability, but are a very important factor in the reduction of the average power production cost for the entire system, as they make it possible to run more efficient units most of the time on what is called a base load, and to use the least efficient units on the peak loads.

This interconnection is now being extended to take in the stations in the districts around Chicago in Illinois and Indiana and further extensions are under consideration. When the new station is built at Michigan City and the high-tension interconnecting circuit is completed, it will be possible for a unit at Waukegan Station to serve as the reserve for one of the Michigan City stations operating through Chicago stations.

This high-tension circuit with the great power stations connected to it will give the city of Chicago and the great industrial district growing up so rapidly around it in Illinois and northern Indiana a source of reliable and cheap electric power second to none in the world, and will be the nucleus of a superpower system which already reaches (with varying voltages) from northern Wisconsin to southeastern Kentucky, and within a year or two will have Chicago connected to Pittsburgh by a continuous tower line at 130,000 volts.

On December 23, 1925, the peak load in the Chicago district was 932,600 kw. By next year the combined load will have passed 1,000,000 kw. and it is likely to reach 1,500,000 by 1930 and 2,000,000 by 1934. By 1930, however, the capacity of the whole district will be in the neighborhood of 1,650,000 kw. In this connection it is stated that it is planned to develop at State Line a station of 1,000,000 kw. capacity, and the first unit will probably be a compound unit with three turbines and generators having a combined capacity of 200,000 kw. The plans contemplate five such units on the site. This situation will have many new features, and so far as the ultimate cost of power is concerned, in all probability will be as much of an advance on Crawford Avenue as Crawford Avenue is in comparison to Calumet.

The associated power companies of the Chicago district also own a large tract of land on the Illinois River within about 150 miles of the city, which within a very few years will be developed to supply electric energy to the Chicago district over a 130,000-volt transmission line. On this same site, moreover, will probably be developed eventually, a great coal-storage and coal-handling plant from which coal will be shipped by water to the Chicago stations after the Illinois waterway is completed.

It may be asked if, through future development of what the late Dr. Steinmetz called the "pool of power" there are any possibilities for further reduction in the cost of energy. It may be said that so far as present-day power-station efficiencies are concerned, we are getting so close to the ultimate possibilities of the steam cycle that further improvement will come only with great difficulty and at prohibitory capital expenditures. Undoubtedly it is impossible to go on reducing the coal rates indefinitely, and reckoned in B.t.u. per kw-hr. there is a figure somewhat beyond which it is impossible to further improve the plant efficiency with any form of the steam cycle. Just what that base line is cannot be stated with absolute assurance of accuracy.

Mr. S. Z. deFerranti of Manchester, England, one of the most expert engineers in the matter of practical thermodynamics now living, told the author, some months ago, that in his opinion there can be no gain in going to a steam pressure of over 850 lb. per sq. in. The theoretical gain that can be achieved above this pressure is so small that the cost of getting it is more than likely to far outweigh the percentage of improvement that can be accomplished. Until we can get metals at reasonable cost which can stand temperatures much higher than we are now using, probably the real limit of practical steam-plant efficiency is somewhere between 12,000 and 13,000 B.t.u. in the fuel per kw-hr. of output, and something less than 14,000 is now in sight with a high-grade coal.

There are, however, other methods of electric power generation that may be developed within a few years, and the combination mercury-vapor and steam cycle of Mr. W. L. R. Emmet indicates the possibility of a station efficiency 20 or 25 per cent better than can be achieved by any form of steam cycle.

While the steam cycle is doubtless approaching its limits of efficiency there are still some possibilities of improvement, but there is more opportunity so far as the immediate future is concerned, in the reduction of capital costs. The Crawford Avenue station cost less per unit of capacity than Calumet, but while the fixed charges on the two stations are about the same, the production costs at Crawford Avenue have been so reduced that the fixed charges on the capital are just about as much as the total cost of operation, so that the reduction of fixed charges is as important as reducing operating charges.

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E. and the A.I.E.E. It is administered by the United Engineering Society as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Applied Elasticity

APPLIED ELASTICITY. By S. Timoshenko and J. M. Lessells. Westinghouse Technical Night School Press, East Pittsburgh, Pa, 1925. Cloth, 6 × 9 in., 531 pp., 391 figures, 95 tables, $6.

THIS book by Timoshenko and Lessells of the Westinghouse Research Staff is distinctly different from any other textbook on mechanics of materials published in the United States.

It consists of two parts: Part I, by Timoshenko, deals with the mathematical analysis of stresses and strains, and Part II, by Lessells, deals with the significance of various physical tests which are made on materials. Most of our textbooks in mechanics of materials have been written from the viewpoint of the structural engineer. This one is rather from the viewpoint of a machine designer.

The chapter headings in Part I outline a field decidedly broader than the usual field covered by a text of this sort. They are: Tension and Compression, Torsion, Stresses in Beams, Deflection of Beams, Statically Indeterminate Cases of Bending, Bending of Bars on Elastic Foundations (includes stresses in railroad track), Direct and Bending Stresses (includes columns), Combined Bending and Twist, Curved Bars, Thin Plates, and Stresses Produced by Dynamical Causes.

In Part I of this book the very large field is covered very concisely. The author to accomplish this uses the method of giving very compact mathematical proofs, or, in some cases, of stating that a certain relation has been proved. In either case he is very careful to give references by means of which any student especially interested can study the proofs in greater detail.

Part II is an interesting attempt to discuss the significance of various physical thoughts. The author is not content with quoting conventional results, but gives a great deal of very careful discussion as to the significance of test results. The chapters on impact tests, on fatigue, and on hardness are especially worthy of study. Other chapters give good discussions of tension and compression, the elastic-stage modifications, and working stresses.

Messrs. Timoshenko and Lessells have produced a noteworthy book, a book which, while it would be rather difficult for the average American undergraduate student, is very valuable as a text or a reference book for advanced students of mechanics of materials and for designers, and which should be studied by every one who is teaching mechanics of materials.

H. F. MOORE.[1]

Urbana, Ill.

Books Received in the Library

ADMINISTRATION OF INDUSTRIAL ENTERPRISES. By Edward D. Jones. New edition. Longmans, Green & Co., New York, 1925. Cloth, 6 × 9 in., 618 pp., illus., tables, $4.75.

The purpose of this book is to present in compact outline a survey of the art of business management as it exists in the United States at this time. The treatment aims to present practice with reasonable fullness of detail but, wherever possible, to deduce and formulate the general principles, or the philosophy, controlling action. The chief outstanding characteristic is the inclusion, for the first time in such a treatise, of a full discussion of the underlying general principles of administration which govern all efficient joint enterprises, whether of a business nature or otherwise. This edition has been thoroughly revised, the new material exceeding the subject-matter of the first edition. The numerous bibliographies have been brought up to date.

AERONAUTICAL METEOROLOGY. By Willis Ray Gregg. Ronald Press Co., New York, 1925. (Ronald Aeronautic Library.) Cloth, 6 × 9 in., 144 pp., illus., diagrams, tables, $2.50.

Intended to give concisely the essential facts concerning the upper air, and to point out their relation to the development and safety of aeronautics. The book is intended for pilots, aeronautical engineers, and others requiring an intimate knowledge of the characteristics of the atmosphere.

ARCHITECTURAL IRON DESIGN AND DETAILING, as Required by the Laws of New York. By Daniel M. Driscoll. D. Van Nostrand Co., New York, 1926. Cloth, 8 × 11 in., 349 pp., illus., plates, tables, $4.

The subjects covered are the designing and detailing of stairs, elevator drip pans, door bucks, door saddles, doors, gratings, sidewalk gratings and other miscellaneous metal work, and fire escapes; and the fabricating and setting of light structural steel. Appendices give useful tables, cuts of stock ornamental molding and shapes, the Building Code of New York City, the Tenement House Law and Labor Law of New York State, the Code of Ordinances and the Rules of the Board of Standards and Appeals of New York City, and a glossary. The book is intended for draftsmen, not beginners. It should be particularly useful because of its careful attention to the laws governing the design of these articles.

BEITRÄGE ZUR GESCHICHTE DER TECHNIK UND INDUSTRIE; Jahrbuch des Vereines Deutscher Ingenieure, 1925. By Conrad Matschoss. V. D. I. Verlag, Berlin, 1925. Cloth, 8 × 11 in., 306 pp., illus., portraits, 16 gm.

This volume of this important historical series is devoted to the industrial history of the Rhinelands and commemorates the thousandth anniversary of their incorporation in Germany. The fifteen essays deal with various phases of the general topic. Among them are papers on the origin and development of the Rhenish-Westphalian industrial region, the history of the Rhenish lignite mines, the iron industry, the brass industry of Aix-la-Chapelle, the boiler industry, the glass industry, the sugar industry, and the cutlery industry.

BUDGETING TO THE BUSINESS CYCLE. By Joseph H. Barber. Ronald Press Co., New York, 1925. (Ronograph Library, no. 38.) Cloth, 5 × 7 in., 115 pp., graphs, tables, $1.25.

The chief objection to the introduction of budgetary methods into industrial organizations is the difficulty of anticipating future conditions with enough accuracy to permit provision for them. This little book describes in detail the methods used by one manufacturer to translate his forecasts of the general trend of business into effective planning of his budget.

BUREAU OF STANDARDS. By Gustavus A. Weber. Johns Hopkins Press, Baltimore, 1925. (Institute for Government Research. Service monographs, no. 35.) Cloth, 6 × 9 in., 299 pp., illus., $2.

The history, activities, and organization of the Bureau of Standards are presented in detail in this volume, which gives a complete

[1] Research Prof. Engrg. Materials, Univ. of Illinois. Mem. A.S.M.E.

account of its purpose, its achievements, and their cost. The laws governing it, the character of its plant, its functions, and its personnel are described, and a full bibliography of the sources of information bearing on it is given.

CASE OF BITUMINOUS COAL. By Walton H. Hamilton and Helen R. Wright. Macmillan Co., New York, 1925. (Institute of Economics. Investigations in industry and labor.) Cloth, 5 × 8 in., 310 pp., $2.50. (Gift of Institute of Economics.)

This is the second volume of the series of studies on coal undertaken by the Institute of Economics. It is an inquiry concerning the effectiveness of the prevailing form of organization in enabling the industry to do the things that the community may reasonably expect from it. It is limited to an analysis of the current situation and of the prevailing tendencies. It does not include any proposals for the reorganization of the industry.

CONDENSED COLLECTION OF THERMODYNAMIC FORMULAS. By P. W. Bridgman. Harvard University Press, Cambridge, 1925. Cloth, 6 × 9 in., 34 pp.

This collection of formulas is intended both for students of thermodynamics and for use in practice. The formulas given apply to systems for which temperature and pressure are a possible set of independent variables; and to systems for which pressure is a function of temperature, and temperature and volume are a possible set of independent variables. The latter table applies to two-phase systems such as water and steam in contact. Illustrative examples show how the tables are used. The author also shows how to extend the tables, in a number of cases, to systems subjected to other external forces than a hydrostatic pressure.

DIE PASSUNGEN UND IHRE ANWENDUNG. By K. Gramenz. Second edition. Beuth-Verlag, Berlin, 1925. (Dinbuch 4.) Cloth, 6 × 8 in., 219 pp., diagrams, tables, 5.50 m.

A manual on the standard tolerances adopted by the German Committee on standards. Explains the theory underlying them, shows how they are to be used in design and in practice, and discusses various details of importance. The book is a practical guide for the designer and manufacturer.

DRAFT AND CAPACITY OF CHIMNEYS. By J. G. Mingle. Combustion Publishing Co.; D. Van Nostrand Co., New York, 1925. Cloth, 5 × 8 in., 339 pp., diagrams, tables $3.50.

In spite of the importance of the chimney to the steam power plant, nothing has been available in book form, this author says, on the determination of its proper size or on the investigation of its draft and capacity performance. This book, which appeared serially in *Combustion*, is intended as an aid to the designer of power plants in determining the proper size for the chimneys and to the operator who wishes to investigate the efficiency of existing chimneys. The author has first considered the subject theoretically and has then modified his results in the light of experimental data until they conform with practice. The book brings together the scattered available information and arranges it logically.

FIRST COURSE IN STATISTICAL METHOD. By G. Irving Gavett. McGraw-Hill Book Co., New York, 1925. Cloth, 6 × 9 in., 358 pp., diagrams, tables, $3.50.

This textbook is based on several years' experience in teaching statistical method to students of business administration, commercial engineering, mathematics, and other sciences at the University of Washington. The course is confined to fundamentals and is intended as an introduction to specialized courses in various fields. It assumes no knowledge of advanced mathematics.

FUEL ECONOMY AND SMOKE PREVENTION. By John B. C. Kershaw. D. Van Nostrand Co., New York, 1925. Cloth, 6 × 9 in., 268 pp., illus., diagrams, $5.

The second edition of this book, under the title Smoke Prevention and Fuel Economy, appeared in 1911 and has been out of print for several years. The death of W. H. Booth has placed the task of revision upon Mr. Kershaw alone. The new edition contains eleven additional chapters, and its value to fuel users has been enhanced by chapters on the grading, washing, and storing of coal, the utilization of waste heat and steam, and on recent large power stations in various countries.

FUELS AND THEIR COMBUSTION. By Robert T. Haslam and Robert P. Russell. McGraw-Hill Book Co., New York, 1926. Cloth, 6 × 9 in., 809 pp., illus., diagrams, tables, $7.50.

This book, based on a course of lectures at the Massachusetts Institute of Technology, discusses in a broad fashion the science of combustion and points out the underlying principles on which further progress in the utilization of fuel must be based. It is intended to give men who use fuel and college students a comprehensive treatment of the subject, with numerous references leading to more intensive study. The book treats first the origin, composition, and production of the natural fuels. The phenomena of combustion and the reactions are then considered in detail. The equipment is described and illustrated by modern apparatus, after which the secondary or manufactured fuels are discussed. The final chapters deal with the flow of fluids and with the transfer of heat.

HEAT TRANSFER AND EVAPORATION. By W. L. Badger. Chemical Catalog Co., New York, 1926. (Modern library of chemical engineering.) Cloth, 6 × 9 in., 306 pp., illus., diagrams, tables, $5.

The first quarter of this book, according to its author, was written to form part of a comprehensive work on heat transfer in all its phases, intended for the student and research worker. In it are discussed the general theory of heat transmission by conduction and radiation, heat transfer by convection in general, and heat transfer between solids and gases, between solids and liquids, and between solids and condensing vapors. The remainder of the present volume is devoted entirely to evaporators and is intended for designers and operators, with special attention to the latter class. Among the topics treated are the design of heaters, evaporator bodies, heat transfer in evaporators, the theory, calculation and operation of multiple-effect evaporators, auxiliaries, the application of evaporators in specific industries, and costs.

HÜTTE, DES INGENIEURS TASCHENBUCH, vol. 1. By Akademischen Verein Hütte. Wilhelm Ernst & Son, Berlin, 1925. Cloth, 5 × 8 in., 1080 pp., diagrams, table, 13.20 mk.

When twenty-five editions of a book have been called for in sixty-eight years, its popularity is evident. In spite of its frequent revision, the new edition shows still further important changes and novelties. An attempt has been made to collect the theoretical principles of all engineering in volume one, and this has necessitated some rearrangement. A new section, technical physics, has been added, and new chapters provided on nomography and the kinetics of gearing. All sections have been carefully revised and new standards have been adopted.

THE INDUSTRIAL MUSEUM. By Charles R. Richards. Macmillan Co., New York, 1925. Cloth, 6 × 10 in., 117 pp., illus., $3.

During the year 1923-24 the author made a survey of foreign museums of industrial art for the American Association of Museums. The present book forms part of the report submitted and deals with industrial museums. The museums described include the Conservatoire des Arts et Métiers, the Science Museum, the Deutsches Museum, and the Technisches Museum für Industrie und Gewerbe in Vienna. There are also a chapter on industrial museums in this country and appendices on various foreign museums devoted to particular subjects, such as traffic, the marine and agriculture. The illustrations include photographs of many of the more interesting exhibits.

MANAGEMENT IN THE FACTORY. By Glenn Lion Gardiner. McGraw-Hill Book Co., New York, 1925. (Industrial education series.) Cloth, 5 × 8 in., 225 pp., $2.

An elementary presentation of the principles of the subject intended for factory foremen, sub-executives, students, and persons desiring a bird's-eye view of the functions of management.

MERCURY-ARC RECTIFIERS AND MERCURY-VAPOUR LAMPS. By J. A. Fleming. London & N. Y., Isaac Pitman & Sons, London and New York, 1925. Cloth, 5 × 7 in., 100 pp., illus., diagrams, $1.75.

Now that this rectifier has become available for electrical work on a large scale and has reached a durability and efficiency comparable with that of dynamos, its working and use are of interest to all electrical engineers. The mercury-vapor lamp has also important commercial and therapeutic uses. The present little

book has been written to supply a small treatise on the mode of operation and the uses of these devices.

OIL INDUSTRY AND THE COMPETITIVE SYSTEM; a Study in Waste. By George Ward Stocking. Houghton Mifflin Co., Boston and New York, 1925 Cloth, 5 × 8 in., 323 pp., diagrams, tables, $3.50.

This work, which received first prize from the Hart, Schaffner & Marx Committee in 1924, is an economic study of the American petroleum industry. The main thesis is: competition in the oil industry means waste. The author reviews the development of the industry, points out ways in which waste is occurring, and discusses present methods of utilizing and marketing oil.

POWER PLANT LUBRICATION. By William Farrand Osborne. McGraw-Hill Book Co., New York, 1925. Cloth, 6 × 8 in., 275 pp., illus., diagrams, tables, $3.

A concise account of the properties of lubricants and of the methods of buying, testing and using them on various classes of power-plant machinery. Intended for operating engineers.

SCIENCE AND SCIENTISTS IN THE 19TH CENTURY. By Robert H Murray. The Sheldon Press, London; Macmillan Co., New York, 1925 Cloth, 6 × 9 in., 450 pp , $5

In this readable book, the author, an eminent English historian, investigates the careers of a number of great scientific discoverers of the nineteenth century and describes the difficulties that they encountered in establishing their doctrines. The book is, in a sense, an assault upon science, for one of its main purposes is to prove that the man of science is no freer from prejudice than his fellow in another calling; that there are just as many preconceived notions in science as there are in theology; and that much that passes under the name of science is stereotyped.

SHIPPING CONTAINERS. By Bronson L. Huestis. Ronald Press Co., New York, 1925. (Ronograph library, no. 37.) Cloth, 5 × 7 in , 139 pp., illus , $1.25

A concise presentation of the essentials of container design and use. The book discusses lumber for boxes and crates; container fastenings; crates; wood, fiber and strawboard boxes; wooden and metal barrels and drums; and cans. Methods of packing are explained, and there is a chapter on the testing of containers.

SIX-PLACE TABLES....with explanatory notes by Edward S. Allen. Second edition. McGraw-Hill Book Co., New York, 1925. Fabrikoid, 4 × 7 in., 144 pp., tables, $1.25

A book of tables of pocket size, containing those that are in constant use by engineering students and, to a certain extent, by practicing engineers. Tables of natural logarithms, of exponential and hyperbolic functions, and of integrals have been added to this edition, as well as an introduction on the theory of logarithms and the use of the tables. The book makes its appeal by its convenient size, rather than by any novelty of arrangement or matter.

STATEMENT AND ENGINEERING REPORT SUBMITTED TO THE INTERNATIONAL JOINT COMMISSION RESPECTING THE PROPOSAL TO DEVELOP THE ST. LAWRENCE RIVER, 1921. By Hydro-Electric Power Commission of Ontario, Toronto, 1925. Cloth, 7 × 10 in., 119 pp.; plans, maps, tables, $7.50.

When the International Joint Commission was empowered, in 1920 by the governments of Canada and the United States to make a special investigation respecting the improvement of the St. Lawrence River, the Hydro-Electric Power Commission of Ontario arranged that the information which it already possessed should be supplemented with the information obtained by additional research and the whole reduced to a report intended to help the International Joint Commission in its investigation. This was done, but as the report has never appeared in print, the Hydro-Electric Power Commission has now published it. The report is directed to plans for power development, but the improvements are planned, it is stated, to safeguard navigation.

STRENGTH OF MATERIALS. By Alfred P. Poorman. McGraw-Hill Book Co., New York, 1925. Cloth, 6 × 9 in., 313 pp., diagrams, tables, $3.

A companion volume to the author's Applied Mechanics, intended for use in undergraduate courses in mechanics. Contains a large number of illustrative examples with detailed solutions and many problems for solution by the student.

U.E.S. Report for 1925

BELOW is a summary of the report of the treasurer of the United Engineering Society for the calendar year 1925. The officers of the U.E.S. for the coming year are: President, W. L. Saunders; First Vice-President, Bancroft Gherardi; Second Vice-President, Lewis D. Rights; Secretary, Alfred D. Flinn; Treasurer, Jacob S. Langthorn; Assistant Treasurer, Henry A. Lardner. *Finance Committee:* Bancroft Gherardi, *Chairman*, Lincoln Bush, J. Vipond Davies, Roy V. Wright, and the President, ex-officio.

The membership of the Board of Trustees for 1926 is as follows:

Representing the Civil Engineers: Lewis D. Rights; Francis Lee Stuart; Lincoln Bush.

Representing the Mechanical Engineers: Roy V. Wright; W. L. Saunders; Walter S. Finlay, Jr.

Representing the Mining Engineers: Walter H. Aldridge; J. Vipond Davies; J. V. N. Dorr.

Representing the Electrical Engineers: H. H. Barnes, Jr.; Bancroft Gherardi; George L. Knight.

Throughout 1925, as in the preceding year, the energies of the trustees were devoted largely to improving the investment of trust funds.

A medallion of General Pershing was placed in the entrance hall of the Engineering Societies Building as a companion to the medallion of Marshal Foch received in 1921. In December, the flags of the 24th Regiment of Engineers were received and placed in the cabinet with the flags of the 27th Engineers received in the previous year.

President Ralph Budd, of the Great Northern Railway, presented to the United Engineering Society a bronze replica of the statue of John F. Stevens, set up last July in Marias Pass through the Rocky Mountains which he discovered. The statuette was placed in the Library.

Memberships of the Founder Societies at the end of 1925 totaled 55,695 and of the Associated Societies 52,205, an aggregate of 107,899 engineers with headquarters in the building.

SUMMARY

OPERATION OF BUILDING

Credit balance January 1, 1925		$ 4,804.64
Revenue from prior years		0.00
Building revenue, 1925	$117,422.17	
Building expenditures, 1925	100,255.80	17,166.37
		$ 21,971.01
Annual payment to Dep. & Renewal Fund.	12,000.00	
Additional payment to Dep. & Ren. Fund	1,305.60	
Miscellaneous adjustments	24.38	13,329.98
Credit balance December 31, 1925		$ 8,641.03

OPERATION OF LIBRARY

Maintenance revenue	41,176.89	
Maintenance expenditures	41,176.89	
Balance December 31, 1925		0.00
Service Bureau revenue	14,615.99	
Service Bureau expenditures & adjustments	15,157.86	
Operating deficit and adjustments		541.87
Credit balance December 31, 1924		1,398.12
Credit balance December 31, 1925		856.25

FUNDS AND PROPERTY

Funds held by U.E.S. December 31, 1925 (book value):	
Depreciation and Renewal	$ 192,623.70
Engineering Foundation	479,542.97
Henry R. Towne Engineering	49,953.13
Library Endowment	97,506.37
Reserve for Depreciation of Capital of Library	4,000.00
General Reserve	10,000.00
John Fritz Medal (U.E.S. custodian)	3,500.00
Total	$ 837,126.17
Real estate owned by U.E.S., cost to Dec. 31, 1925	1,966,569.44
Operating cash and petty cash	8,310.38
Accounts receivable	4,389.45
Value of Library (as appraised for insurance)	329,000.00
Total property for which U.E.S. is trustee or custodian..	$3,145,395.44

THE ENGINEERING INDEX

(Registered United States, Great Britain and Canada)

THE ENGINEERING INDEX presents each month, in conveniently classified form, items descriptive of the articles appearing in the current issues of the world's engineering and scientific press of particular interest to mechanical engineers. At the end of the year the monthly installments are combined along with items dealing with civil, electrical, mining and other branches of engineering, and published in book form, this annual volume having regularly appeared since 1906. In the preparation of the Index by the engineering staff of The American Society of Mechanical Engineers some 1200 technical publications received by the Engineering Societies Library (New York) are regularly reviewed, thus bringing the great resources of that library to the entire engineering profession.

Photoprint copies (white printing on a black background) of any of the articles listed in the Index may be obtained at a price of 25 cents a page. When ordering photoprints identify the article by quoting from the Index item: (1) Title of article; (2) Name of periodical in which it appeared; (3) Volume, number, and date of publication of periodical; (4) Page numbers. A remittance of 25 cents a page should accompany the order. Orders should be sent to the Engineering Societies Library, 29 West 39th Street, New York.

AERONAUTICAL INSTRUMENTS

Calibration. An Altitude Chamber for the Study and Calibration of Aeronautical Instruments, H. J. E. Reid and O. E. Kirchner. Nat. Advisory Committee Aeronautics—Tech. Notes, no. 229, Nov. 1925, 13 pp., 7 figs. Design and construction of altitude chamber in which pressure and temperature can be varied independently, carried out at Langley Memorial Aeronautical Laboratory, Va.; temperatures ranging from +20 deg. to —50 deg. cent. are obtained by the expansion of CO_2 from standard containers, used for calibrating research instruments under altitude conditions simulating those up to 45,000 feet.

AERONAUTICS

Developments, U. S. A. Eleventh Annual Report. Nat. Advisory Com. for Aeronautics—Administrative Report, 1925, 59 pp. Organization and activities of National Advisory Committee; presents stages of aviation including aerodynamics, trend of airplane design, structural materials, airships, aeronautical research in U. S. A. and its relation to national defense, etc. See also abstract in Aviation, vol. 19, no. 25, Dec. 21, 1925, pp. 873–874.

McCook Field Review, J. F. Curry. Aviation, vol. 20, no. 2, Jan. 11, 1926, pp. 47–49, 4 figs. Review of aeronautical engineering development during past; interesting designs and new equipment developed.

German Developments. Report of the German Scientific Society for Aeronautics (WGL) in Munich, September 1925 (Bericht über den Verlauf der XIV. Ordentlichen Mitgliederversammlung der Wissenschaftlichen Gesellschaft für Luftfahrt, etc.), G. v. Scheve. Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 16, no. 19, Oct. 14, 1925, pp. 399–407, 1 fig. Review of papers by Dornier on all-metal design and experiments with smooth metallic covering; by Brandenburg, on need of training fliers, emphasizing that ideal should not be that of chauffeur, but that of sea captain; by A. Behm, on his echo sounder; by Schrieber, on Institute of Aerial Law recently founded; by Hermann, who points out that thick wing profile is not in all cases advisable, that it might be desirable to place propeller far to rear, and emphasizes importance of slotted wing; by Lachmann, on "fall-proof" airplanes, and improved transverse rudder action developed in England; and other papers.

AIR COMPRESSORS

Types. A New Form of Air Compressor, H. S. Hele Shaw and T. E. Beacham. Colliery Guardian, vol. 130, no. 3385, Nov. 13, 1925, pp. 1159–1161, 13 figs. Describes Hele-Shaw Beacham compressor showing almost perfect balance at all speeds, owing to fact that reciprocity movement between cylinder and piston is really relative and not absolute, and fact that the oil which is necessarily employed for lubrication acts as packing not only for the pistons, but as a seal for central valve.

AIR CONDITIONING

Humidity Chart. A New Humidity Chart, V. A. Nekrassoff. Heat. & Vent. Mag., vol. 22, no. 12, Dec. 1925, pp. 65–68, 6 figs. Effective use of the nomographic method of presentation in simplifying air-conditioning calculation.

AIRCRAFT CONSTRUCTION MATERIALS

Metals, Testing. Testing Metals for Aircraft, N. S. Otey. Iron Age, vol. 116, nos. 25 and 26, Dec. 17 and 31, 1925, pp. 1660–1664 and 1797–1800, 21 figs. Selecting representative samples; proper design of test specimens and methods of loading them. New proposed standard specifications and methods for testing light alloys.

AIRPLANE ENGINES

Air-Cooled. The Super Rhone Engine. Aviation, vol. 20, no. 4, Jan. 25, 1926, p. 113, 1 fig. Well-known rotary engine remodeled into air-cooled radial type.

Altitude Tests. Effect of Altitudes on the Power of Aero-Engines, A. Kobayashi. Soc. Mech. Engrs.—Jl., vol. 28, no. 101, Sept. 1925, pp. 551–601, 18 figs. Discusses decrease in power output of engines due to altitude and develops formulas for calculation; supercharging and increasing compression ratio; effect of richness of fuel gas, etc. (In Japanese.)

Flow Through Valve. Potential Flow in Engine Valves, B. Eck. Nat. Advisory Committee Aeronautics—Tech. Memo., no. 343, Dec. 1925, 20 pp., 25 figs. Attempts to determine by exact methods the nature of flow in valves under various restricted conditions, distinguishing two kinds of flow in simple flat-seated valves, for small valve lift and for greater valve lift.

Fuel Strainers, Clogging of. The Clogging of Fuel Strainers, A. C. Zimmerman and E. R. Irwin. Air Service Information Circular, vol. 6, no. 542, Oct. 1, 1925, 3 pp., 4 figs. Report prepared from study of data contained in several isolated reports; concludes that clogging of fuel strainers is attributable: to accumulation of a jelly-like precipitate of hydrated aluminum oxide, caused by corrosion of aluminum parts of fuel system by water, to accumulation of a fibrous material, either asbestos or cotton fibers, on the screen, etc.

Fuels. Fuels for High-Compression Engines, S. W. Sparrow. Nat. Advisory Committee Aeronautics—Report, no. 232, Jan. 15, 1925, 20 pp., 13 figs. Report based on results of tests made by Bureau of Standards emphasizing fact that there may be a difference between fuel's ability to resist detonation and its ability to resist preignition; also discusses properties essential to a satisfactory fuel for high compression engines; certain fuels, benzol and alcohol in particular, are discussed in some detail.

Rating. The Horse Power Rating Formula for Aero Engine, O. Sugimoto. Soc. Mech. Engrs.—Jl., vol. 28, no. 101, Sept. 1925, pp. 609–615. Discusses formulas for calculating brake horsepower, assuming brake mean effective pressure as constant; i.e., expressing brake horsepower as a function of cylinder bore, piston speed, and number of cylinders; recommends three rating formulas for vertical and vee, radial and rotary engines.

Rickenbacker. Rickenbacker Enters Aircraft Field with 75 Hp. Radial Engine, L. S. Gillette. Automotive Industries, vol. 53, no. 25, Dec. 17, 1925, pp. 1011–1012, 2 figs. Said to be first motor developed in United States especially for private operators without regard to Government specifications; weighs about 2.4 lb. per hp. fully equipped; dependability a feature.

Test Regulations. England Prescribes Difficult Tests for Airplane Engines. Automotive Industries, vol. 53, no. 25, Dec. 17, 1925, p. 1012. Review of revised test regulations issued by British Air Service.

AIRPLANE PROPELLERS

Manufacture. How Curtiss Makes Metal Aircraft-Propellers, F. H. Colvin. Am. Mach., vol. 63, no. 26, Dec. 24, 1925, pp. 1009–1012, 16 figs. Outline of methods used in making Reed propeller; sawing, milling, twisting, boring, mounting hub, and balancing ready for use.

Vibrations. An Experimental Study of the Vibrations in the Blades and Shaft of an Airscrew, A. Fage. Aeronautical Research Com.—Reports and Memoranda, no. 967, Sept. 1925, 16 pp., 10 figs. Discusses determination of frequencies of flexural vibrations in blades and shafts of rotating airscrews from analysis of sound emitted; gives results of experiments carried out on four airscrews of different blade shape with variable width and geometrical pitch.

AIRPLANES

Airfoils. An Investigation of the Air-Flow Pattern in the Wake of an Aerofoil of Finite Span, A. Fage, L. F. G. Simmons. Roy. Soc. of Lond.—Philosophical Trans., vol. 225, no. A632, 1925, pp. 303–330, 13 figs. Investigation to obtain more complete picture of disturbance beyond an airfoil of infinite span and to map out changes which occur in extent and distribution of vorticity in wake as it passes downstream.

Altitude. A New Altitude Airplane, A. M. Jacobs. Aviation, vol. 20, no. 2, Jan. 11, 1926, pp. 52–53, 1 fig. Details of OCO5A, of Engineering Division, McCook Field; side-type supercharger has been installed.

Autorotation Measurement. Autorotation Measurements on a Model Aeroplane with Zero Stagger, F. B. Bradfield and L. P. Coombes. Aeronautical Research Committee—Reports & Memoranda, no. 975, April 1925, 7 pp., 4 figs. Measurements up to 52-deg. incidence; autorotation commenced with 17 deg. and continued to beyond 52 deg., curve was then flattened off; large range and rates of autorotation seemed to depend on biplane arrangement rather than on any peculiarity of the wing section.

Beams. The Action of Ribs in Internally Trussed Wings with Two Transverse Beams (Ueber die Verbundwirkung von Rippen in freitragenden, zweiholmigen und verspannungslosen Flugzeugflügel), K. Thalau. Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 16, no. 20, Oct. 28, 1925, pp. 415–445, 78 figs. Gives thorough investigation, both theoretical and experimental, covering initial influence of all members. Report of German Experimental Inst. for Aviation.

Biplanes, Lateral Control. The Lateral Control of a Biplane by Combined Use of Ailerons and Varying Leading Edge Slots, G. P. Douglas, F. B. Bradfield, and A. S. Hartshorn. Aeronautical Research Com.—Reports and Memoranda, no. 973, April, 1925, 14 pp., 13 figs. Discusses measurement of rolling and yawing moment due to slot used in conjunction with balanced ailerons on wings of Avro section; results previously found for monoplane are confirmed for biplane at zero rate of roll.

Commercial. The Lessons of Six Years' Experience in Air Transport, S. Brancker. Roy. Aeronautical Soc.—Jl., vol. 29, 179, Nov. 1925, pp. 552–585. Discusses experience with airplanes and seaplanes to evolve therefrom most important problems to be placed before scientists and designers interested in aviation, including safety, reliability, economy; aircraft specifications of the British government, etc.

Development. The Aeroplane; Past, Present and Future. L. N. W. Colin. Rochester Engr., vol. 4, no. 6, Dec. 1925, pp. 127–129 and 133–135. Discusses airplane development as based on laboratory tests; constituents of airplanes, landing conditions, etc.

Farman Goliath. New French Load Carrying Altitude Records. Aviation, vol. 20, no. 1, Jan. 4, 1926, pp. 10–11, 3 figs. Latest Farman 2000-hp. Super Goliath, type F140-Bn. 4, biplane with 4 engines mounted in tandem pairs, on lower wing, one each side of fuselage, essentially a bombing plane.

Flying Boats. See FLYING BOATS.

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NOTE.—The abbreviations used in indexing are as follows:

Academy (Acad.)
American (Am.)
Associated (Assoc.)
Association (Assn.)
Bulletin (Bul.)
Bureau (Bur.)
Canadian (Can.)
Chemical or Chemistry (Chem.)
Electrical or Electric (Elec.)
Electrician (Elecn.)
Engineering (Engr.[s])
Engineering (Eng.)
Gazette (Gaz.)
General (Gen.)
Geological (Geol.)
Heating (Heat.)
Industrial (Indus.)
Institute (Inst.)
Institution (Instn.)
International (Int.)
Journal (Jl.)
London (Lond.)
Machinery (Machy.)
Machinist (Mach.)
Magazine (Mag.)
Marine (Mar.)
Materials (Matls.)
Mechanical (Mech.)
Metallurgical (Met.)
Mining (Min.)
Municipal (Mun.)
National (Nat.)
New England (N. E.)
Proceedings (Proc.)
Record (Rec.)
Refrigerating (Refrig.)
Review (Rev.)
Railway (Ry.)
Scientific or Science (Sci.)
Society (Soc.)
State names (Ill., Minn., etc.)
Supplement (Supp.)
Transactions (Trans.)
United States (U. S.)
Ventilating (Vent.)
Western (West.)

Fokker. Development of Airplanes after the War and Commercial Types in Particular (De ontwikkeling van het vliegtuig na den oorlog en van het verkeersvliegtuig in het bijzinder), A. H. G. Fokker. Ingenieur, vol. 40, no. 44, Oct. 31, 1925, pp. 925–934, 25 figs. Discusses parts and construction of standard type of airplane; variation of weight, load, speed, altitude, rising speed, etc., of military planes, 1918–25; stability, control; manufacturing planes, single and double deckers, etc.

Fuselage. The Static Test of the DH-4 M2 Fuselage, D. B. Weaver. Air Service Information Circular, vol. 6, no. 512, June 1, 1925, 8 pp., 9 figs. Test carried out in accordance with requirements of U. S. Air Service Order No. 2015–28, concluding that fuselage supported required torsional load satisfactorily, that structural strength is great enough, but to insure against disalignment due to compression load, gusset plate should be changed as previously suggested.

Gliders and Light. Gliding and Light Airplanes (Vom Segel- und Kleinflugzeug), A. Pröll. Zeit. des Vereines deutscher Ingenieure, vol. 69, no. 47, Nov. 21, 1925, pp. 1474–1476, 2 figs. Place of glider in air transportation and its importance in development of light airplanes; purpose and utility of light plane; utilization of aerology in light-plane traffic; other forward-drive possibilities (oscillating drive), and its utilization for alternating glider and motor-airplane flight, as future problem.

Passenger. The California "Coupe-Cabin" Plane. Aviation, vol. 19, no. 25, Dec. 21, 1925, p. 882, 2 figs. Closed-cabin passenger airplane suitable for private touring; equipped with 300-hp. Hispano-Suiza engine.

Powell. The Powell Light Plane. Flight, vol. 17, no. 53, Dec. 31, 1925, pp. 852–855, 10 figs. Details of new American machine with Bristol Cherub engine designed by Prof. Powell of Univ. of Detroit; fuselage is plywood-covered monocoque structure built on $^3/_8$-in. plywood formers, giving very robust construction.

The Powell Racer. Aviation, vol. 20, no. 1, Jan. 4, 1926, pp. 12–14, 7 figs. Light plane incorporating many good features of larger designs, equipped with Bristol "Cherub" engine rated at 30 hp.; chassis is Vee type with divided axle.

Rudders, Pressure on. Report on Experiments to Measure Pressures on Transverse Rudders in Flight (Bericht über Versuche und Druckmessungen an Querrudern im Fluge), F. Budig. Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 16, no. 16, Aug. 28, 1925, pp. 307–310, 10 figs. Experiments to determine difference in transverse rudder action by measuring air pressures, and observation during flight; examines effect of lateral currents in flight; transverse stability of airships.

Strength Calculation. Strength Calculations on Airplanes, A. Baumann. Nat. Advisory Aeronautics—Tech. Memo., no. 341, Dec. 1925, 23 pp. Discusses allowable stresses and safety factor in airplanes, yield point of materials, value of elongation, etc.

Wind-Tunnel Tests. Wind Tunnel Test of Transport Study, C. E. Archer. Air Service Information Circular, vol. 6, no. 533, Sept. 1, 1925, 13 pp., 18 figs. Details of testing to determine aerodynamic characteristics of proposed transport propeller, drawing M-4012.

Wire Suspensions in Wind Tunnel Experiments, J. Kerneis. Nat. Advisory Committee Aeronautics—Tech. Memo., no. 342, Dec. 1925, 14 pp., 7 figs. Discusses substitution of wire balance for rigid supports of the models, principal advantages and drawbacks of wire balance; shows importance which errors inherent in wire suspension may assume, and under what conditions accuracy may be obtained.

Wings. Model Tests with a Systematic Series of 27 Wing Sections at Full Reynolds Number, M. M. Munk and E. W. Miller. Nat. Advisory Committee Aeronautics—Report, no. 221, Dec. 23, 1925, 18 pp., 27 figs. Results of tests of wing sections characterized by small travel of the center of pressure, tested at 20-atmos. pressure in variable-density wind tunnel of the Nat. Advisory Committee on Aeronautics, giving consistent results and showing that for stable sections a small effective camber, a small effective S-shape and thickness of 8 to 12 per cent lead to good aerodynamic properties.

Wire Wheels. Effect of Spoke Lacing on the Physical Properties of Airplane Wire Wheels, C. J. Cleary. Air Service Information Circular, vol. 6, no. 537, Sept. 1, 1925, 16 pp., 11 figs. Details of investigation to determine effect of different types of wheel lacings, five types of lacings being used including radial spokes, tangential spokes, and a combination of both, having the hubs centered or off center as a bracing for side thrust, and having the spoke in the bead seat of the rim only and in both bead seat and drop center of the rim.

AIRSHIPS

Shenandoah Disaster. The Shenandoah Court Findings. Aviation, vol. 20, no. 2, Jan. 11, 1926, pp. 44–46. Court of Inquiry resolves its report into series of facts and opinions relating to Shenandoah in particular and airships in general.

ALIGNMENT CHARTS

Construction. Alignment Charts (Flugtlinietavler), J. Rybner. Ingeniören, vol. 34, no. 42, Oct. 17, 1925, pp. 501–515, 20 figs. Discusses theory, operations with rectangular and polar coördinates and complex hyperbolic functions; examples of multiplication, solution of equations of first and second degree, vectors, hyperbolic tangents of complex arguments, etc.

ALLOY STEEL

Production, United States, 1925. Alloy Steels Gain Recognition, J. D. Knox. Iron Trade Rev., vol. 78, no. 1, Jan. 7, 1926, pp. 15–18, 1 fig. Production, exclusive of sheets, exceeds 1,000,000 tons annually; automotive and machine-tool industries absorb 85 per cent of national output; includes partial list of alloy-steel applications.

ALLOYS

Aluminum. See ALUMINUM ALLOYS.

Brass. See BRASS.

Lead. See LEAD ALLOYS.

ALUMINUM

Cast Block, Effect of Cold Rolling. The Behavior of Non-Homogeneous Cast Aluminum Blocks under Cold Rolling (Das Verhalten inhomogener Aluminium-Gussblöckchen beim Kaltwalzen), E. Seidl and E. Schiebold. Zeit. für Metallkunde, vol. 17, nos. 7, 9, 10 and 11, July, Sept., Oct. and Nov. 1925, pp. 221–226, 283–288, 320–328 and 365–368, 113 figs. Full account of very thorough research into effect of cold rolling on non-homogeneous specimens of cast aluminum; variations in chemical composition and in physical properties; results of cold-rolling tests, which explain fact that structure of material has profound influence on its amenability to mechanical working; size and arrangement of crystals, and their orientation with respect to direction of forces applied, appreciably affect their behavior during process of working. See also translated abstract in Metallurgist (supp. to Engineer), Dec. 25, 1925, pp. 189–191, 3 figs.

ALUMINUM ALLOYS

Piston Castings. Aluminum Alloys for Piston Castings Must Meet Varied Requirements, R. J. Anderson. Automotive Industries, vol. 53, no. 25, Dec. 17, 1925, pp. 1030–1034, 6 figs. Points out that they must be low in cost, of ingredients easily alloyed, handle well in foundry, be easy to machine, have good mechanical and physical properties and proper microstructure.

ALUMINUM BRONZE

Alcumite. Alcumite—An Aluminium Bronze Alloy, P. D. Schenck. Am. Mach., vol. 64, no. 2, Jan. 14, 1926, pp. 61–64, 7 figs. Physical and chemical characteristics; methods for machining, forging, rolling, spinning, welding; typical applications in service; partial view of its range of usefulness.

AMMONIA COMPRESSORS

Nomographic Charts for. Nomographic Chart for the Refrigerating Engineer, W. H. Motz. Ice and Refrigeration, vol. 69, nos. 2, 3, 4, 5 and 6, Aug., Sept., Oct., Nov. and Dec. 1925, pp. 104–106, 160–161, 211–212, 273–274 and 381–382, 5 figs. Aug.: Discusses nomographic chart for determining horsepower of ammonia compressors, heat removed in ammonia condenser, and amount of water required for ammonia condenser for any condition of operation. Sept.: Illustration of formula for determining mean effective pressures of ammonia; power requirements; example of use of formula for calculation of mean effective pressures at standard conditions in evaporator and condenser. Oct.: Formula and chart for number of ice cans per ton of ice; directions for use of chart. Nov.: Formulas and charts for determination of area of heat-transmitting surfaces for any operating condition; amount of pipe required for ice tanks. Dec.: Formula and nomographic chart for determining pressure due to height of any liquid, such as brine, oil, or water; formula and chart for power required for pumping any liquid such as brine, water, or oil against any head.

AMMONIA CONDENSERS

Operation. Operation and Care of Ammonia Condensers, H. R. Halterman. Refrigeration, vol. 37, no. 4, Oct. 1925, pp. 48–50. Discusses specification of condensers; atmospheric, double pipe, surface, and submerged, etc.; condenser water supply, cooling pumps and cooling towers; non-condensable gases.

APPRENTICES, TRAINING OF

Foundry. Foundry Apprentice Training. Metal Industry (Lond.), vol. 27, no. 26, Dec. 25, 1925, pp. 607–608. Defence of British methods.

The Training of Foundrymen, E. Ronceray. Foundry Trade Jl., vol. 32, no. 486, Dec. 10, 1925, pp. 491–495, 7 figs.; and (discussion), no. 487, Dec. 17, 1925, pp. 511–512. Foundry training from apprenticeship to foundry technical high school; training of artisans; apprenticeship pamphlet; apprenticeship in foundry or at school; choice of instructor; foundry instruction courses; influence of staff; actual state of apprenticeship in France; training of foremen and of foundry executives; foundry high school. See also Metal Industry (Lond.), vol. 27, no. 24, Dec. 11, 1925, pp. 563–564 and 566–567.

Railways. The Training of Railroad Apprentices, E. M. Sawyer. Ry. Rev., vol. 77, no. 26, Dec. 26, 1925, pp. 946–948, 3 figs. Courses in curriculum in railroad department of International Correspondence Schools.

ASH HANDLING

Machinery, Operation of. Operation of Ash Handling Machinery. Power Plant Eng., vol. 30, no. 1, Jan. 1, 1926, pp. 76–77, 3 figs. Discusses care of various types of equipment in use and method of testing for combustible in ash.

AUTOMOBILE ENGINES

Anti-Freeze Solution. Glycol Advocated as Anti-Freeze Solution. Automotive Industries, vol. 53, no. 25, Dec. 17, 1925, p. 1025, 2 figs. Compound is intermediate between alcohol and glycerine in regard to composition and physical properties.

Crankcase-Oil Dilution. Dilution Effects on Friction Coefficients and Bearing Temperatures, A. Le Roy Taylor. Soc. Automotive Engrs.—Jl., vol. 18, no. 1, Jan. 1926, pp. 41–45, 10 figs. Describes tests made to ascertain degree of crankcase-oil dilution beyond which it is unsafe to run engine bearing, and analyzes data obtained, details of apparatus used being specified; results of tests indicate that dilution of oil up to 50 per cent has no bad effect upon engine as regards increased friction and temperatures of bearings, although dilution may be injurious from other standpoints.

Vibration. The Importance of Freedom from Vibration in Passenger Car Engines, D. Fergusson. Rochester Engr., vol. 4, no. 6, Dec. 1925, pp. 124–126, 2 figs. Discusses vibrations in 6-cylinder and 8-cylinder engines, and research to eliminate vibration.

AUTOMOBILE FUELS

Alcohol. The Power Alcohol Problem, H. Langwell. Indus. Chemist, vol. 1, no. 1, Feb. 1925, pp. 14–16. Describes from an economical standpoint possibilities of production of power alcohol from enormous quantities of cellulosic material at our disposal, not only at home in form of waste straw and fibrous material, but also abroad in form of tropical vegetation; shows that alcohol as a fuel for internal-combustion engines is not necessarily inferior to gasoline.

Anti-Knock Compounds. Anti-detonators (Gli antidetonanti), Ariano. Giornale di Chimica Industriale ed Applicata, vol. 7, no. 10, Oct. 1925, pp. 573–575. Discusses theories of phenomenon of detonation, the use of anti-knock compounds and the percentage to be added to fuel, action of tetraethyl lead, etc.; concludes that whatever the action, substances exist which, added to fuel in very minute quantities, give an increased ratio of volumetric compression and therefore increase efficiency.

Anti-Knock Motor Fuel Is Already Here; Cracking Stills Make It, P. Truesdell. Nat. Petroleum News, vol. 17, no. 47, Nov. 25, 1925, pp. 54–56, 1 fig. Production of anti-knock fuel by cracking; anti-knock gasoline; coal-tar naphtha containing benzol; California natural gasoline containing its lighter fraction hydrocarbons; gasoline produced by thermal composttions of hydrocarbons.

Standardized Anti-Knock Fuel Seems Necessary for Best Results, P. Truesdell. Nat. Petroleum News, vol. 17, no. 49, Dec. 9, 1925, p. 41. Discusses determination of anti-knock fuel, anti-knock compounds, tetraethyl lead.

Tetraethyl Lead as "Anti-Knock" Reagent. Chem. Age (Lond.), vol. 13, no. 338, Dec. 5, 1925, pp. 572–573. Details of preparation and properties of tetraethyl lead and various theories of its action as an anti-knock reagent, including new French explanation. (Transl. from Revue des Produits Chimiques.)

Synthetic. The Production of Synthetic Liquid Fuels, A. P. Sachs. Combustion, vol. 13, no. 6, Dec. 1925, pp. 358–360. Discusses absolute necessity of having gasoline or a substitute as motor fuel, storage battery drive being limited; production of synthetic fuels by the Badische and Bergius processes.

AUTOMOBILE INDUSTRY

Bureau of Standards Research. Bureau of Standards Builds New Brake Lining Testing Machines. Automotive Industries, vol. 53, no. 25, Dec. 17, 1925, pp. 1016–1018, 2 figs. Closer readings obtained with apparatus now in use; study of linings has resulted in production of higher quality; Bureau has worked out standard test for fuels; other work under way.

AUTOMOBILES

Bodies. British Body Designers Seek Comfort and Improved Appearance, K. W. Stillman. Automotive Industries, vol. 53, no. 25, Dec. 17, 1925, pp. 1022–1024, 3 figs. Trend of new design is in line with American progress; pyroxylin finishes gain in popularity; unique means of body suspension and top regulation.

Brussels Show. European Trend Is Toward Elimination of Brakes on Rear Wheels, W. F. Bradley. Automotive Industries, vol. 53, no. 27, Dec. 31, 1925, pp. 1112–1114, 10 figs. Transmission and front-wheel brakes are hooked up to get 4-wheel braking effect; several new French and Belgian models make appearance at Brussels show.

Chrysler. 92 Hp. "Imperial" Six Model Is Added to Chrysler Line, L. S. Gillette. Automotive Industries, vol. 53, no. 27, Dec. 31, 1925, pp. 1098–1102, 8 figs. Larger 6-cylinder car in 6 body styles, with 120 and 127 in. wheelbase, rated at 80 m.p.h.

Headlights. Automobile Headlighting Symposium. Soc. Automotive Engrs.—Jl., vol. 17, no. 6, Dec. 1925, pp. 559–577, 6 figs. Contains following papers and discussions: Fundamental Principles of Automobile Headlighting, H. M. Crane; Headlights, J. H. Hunt; Invariable and Asymmetrical Lighting, P. W. Cobb; Lessening of Glare by Colored Shields, J. W. Lord; Improvements in Headlighting, R. N. Falge; Specifications for Headlights, W. D'A. Ryan.

Problem of Glare, Especially from Automobile Headlights (Zur Frage der Blendung, insbesondere durch Automobilscheinwerfer), R. Weigel. Zeit. fur Technische Physik, no. 10, 1925, pp. 504–510. Discusses definition and characteristic types of glare; physiological and physical nature of glare and factors determining it; method for eliminating glare.

The Status of Headlights. Soc. Automotive Engrs.—Jl., vol. 18, no. 1, Jan. 1926, pp. 25–26. Plans to improve unsatisfactory night-driving conditions discussed at meeting of Society's Research Subcommittee for Headlighting.

Paige. New, Smaller Paige to Be Built in Five Body Styles. Automotive Industries, vol. 54, no. 1, Jan. 7, 1926, pp. 23–24. 1 fig. 5-passenger sedan has 6-cylinder engine and 4-wheel brakes.

Physical Testing. Getting Facts for Automobile Designers, K. H. Condit. Am. Mach., vol. 64, no. 1, Jan. 7, 1926, pp. 9–12, 6 figs. How General Motors Corp. is securing comparative test data on automobile performance that are invaluable to designing engineers; describes instruments used for measuring various performance characteristics.

Pontiac. General Motors Enters Low-Priced Six Field with New Pontiac, W. L. Carver. Automotive Industries, vol. 54, no. 1, Jan. 7, 1926, pp. 6–9, 7 figs. Car with 186-cu. in. motor and 110-in. wheelbase will be offered in coach and coupé types; Fisher bodies; Duco finish; 2-wheel brakes.

Proving Grounds for. Automotive Proving Grounds of the General Motors Corporation, O. T. Kreusser. Soc. Automotive Engrs.—Jl., vol. 18, no. 1, Jan. 1926, pp. 27–32, 11 figs. Layout, facilities and activities relating to making road tests of motor vehicles at 1125-acre proving grounds of Gen. Motors Corp. near Detroit; activities include carrying on of endurance tests and experimental-car operation by each division of Corporation and comparative engineering and endurance tests of such cars in current production as may be of interest; various tests made are enumerated, and details of methods of test procedure are stated, together with descriptions of testing equipment.

Stutz. Many Original Features in Design of New Stutz Vertical Eight, W. L. Carver. Automotive Industries, vol. 53, no. 27, Dec. 31, 1925, pp. 1090–1097, 10 figs. "Safety" chassis departs from conventional in numerous details.

Willys-Knight. Smaller Willys-Knight Six to Make Debut at New York Show, L. S. Gillette. Automotive Industries, vol. 54, no. 1, Jan. 7, 1926, pp. 12–16, 9 figs. New car powered with 180-cu. in. sleeve-valve engine; has 7-bearing crankshaft, single dry plate clutch and air cleaner.

AVIATION

Air Racing. An Ideal for Air Racing, E. T. Allen. Aviation, vol. 19, no. 25, Dec. 21, 1925, pp. 880–881, 1 fig. Points out that greatest airplane race of year, the Deutsche Rundflug, which took place in Germany during summer, was from many points of view, most remarkable single aeronautical event since the war; lessons which can be learned from the Round-Germany Flight.

Canada. Report on Civil Aviation. Dominion of Canada, Dept. of Nat. Defence, 1924, 56 pp., 10 figs. Review of progress made in 1923, including commercial flying, Canadian air forces and operations, aircraft industry of Canada, aerial photographic mapping, etc.

Report on Civil Aviation. Dominion of Canada, Dept. of Nat. Defence, 1925, 110 pp., 33 figs. Discusses progress in aviation during 1924 in Canada and other countries; control of civil aviation, commercial flying, Canadian air-force operations, aircraft industry, etc.

Civil. Civil Aviation. Soc. Automotive Engrs.—Jl., vol. 18, no. 1, Jan. 1926, pp. 46–47. Legal status and control; Government program regarding civil and industrial uses of aircraft; public and business support; operations abroad; operations in United States.

Commercial. Commercial Aviation's Present Phase, D. W. Douglas. Soc. Automotive Engrs.—Jl., vol. 18, no. 1, Jan. 1926, pp. 38–40. Defines military, commercial and private aviation activities and presents outline of aviation history to date; enumerates many factors that have tended to stimulate or to retard aviation progress and discusses present conditions and future trends; aviation learned during war; lack of known constant factors for use in estimating initial costs, operating charges and maintenance expense constitutes great present barrier to aviation progress.

United States Air Service. The Lampert Committee Report. Aviation, vol. 19, no. 26, Dec. 28, 1925, pp. 906–909. Report of select committee of inquiry into operations of U. S. Air Service.

B

BEARINGS

Oil-Ring. Some Limitations of Oil Ring Bearings, E. G. Gilson. Am. Mach., vol. 63, no. 26, Dec. 24, 1925, pp. 1005–1007, 3 figs. Why oil-ring bearings fail at high speeds; lubricating and cooling functions of oil; how oil-ring bearings may be made successful by correct grooving.

BEARINGS, BALL

Steel. Possibilities of Defects in Structure of Ball-Bearing Steel (Fehlermöglichkeiten im Gefügeaufbau von Kugellagerstahl), Houdremont. Motorwagen, vol. 28, no. 28, Oct. 10, 1925, pp. 616–618, 6 figs. It is shown that production of faultless material in melting process is not sufficient guarantee for quality of finished product; sharper control and inspection of work is likewise necessary in order to insure quality of final product.

BLAST FURNACES

Capacity Rating. Rating the Capacity of a Blast Furnace. Iron Age, vol. 117, no. 4, Jan. 28, 1926, p. 283. Review of discussions at meeting of Southern Ohio Pig Iron & Coke Assn.; method of allowing 350 operating days per year; performance per lining; relining in 6 to 8 weeks.

Practice, 1925. Ironmakers Study Quality of Product, R. H. Sweetser. Iron Trade Rev., vol. 78, no. 1, Jan. 7, 1926, pp. 20–22, 4 figs. Blast-furnace practice in 1925; carbon in pig iron; oxidizing of pig iron; blast-furnace capacity; new stacks are shorter and broader.

BOILER FEEDWATER

Deaeration. Feed-Water Deaeration Increases Plant Economy, J. R. McDermet. Power Plant Eng., vol. 29, no. 24, Dec. 15, 1925, pp. 1268–1270, 3 figs. Deaerators are insurance against corrosion and replace other equipment.

Systems. Feed Water Systems. Power Plant Eng., vol. 30, no. 1, Jan. 1, 1926, pp. 45–49, 4 figs. Methods of purification, hot and cold chemical treatment, evaporation, deaeration, recirculation and filtering; methods of heating; boiler-feeding arrangements, pumps, methods of control, economizer operation.

Treatment. German Symposium on Feedwater Treatment (Vorträge über Speisewasserpflege auf der Darmstädter Tagung der Vereinigung der Grosskesselbesitzer E. V. in Berlin), Frederking. Wärme, vol. 48, no. 43, Oct. 23, 1925, pp. 542–544. Summary of main features of papers read at Darmstadt meeting of German Assn. of Large Boiler Owners. Either described properties of raw feedwater in various parts of Germany; Splittgerber explained various methods of treatment employed; so-called "currentless" electrolytic method of protecting boilers is used in about 100 installations in Germany, generally with satisfactory results; effect of caustic soda solution on steel.

New Agents for Boiler Scale Prevention (Neue Mittel zur Verhutung von Kesselstein), E. Herms. Brennstoff- u. Wärmewirtschaft, vol. 7, no. 16, Aug. (2d no.) 1925, pp. 316–319. Discusses degrees of water hardness; gives German, English, French equivalents; describes "Kespurit," "Verti," and "BKZ" agents, especially last, which precipitates scale as a flocculent sludge, and is very effective.

BOILER FIRING

Cleaning Fires. Method of Cleaning the Boiler Fires at a Pumping Station. Eng. & Boiler House Rev., vol. 39, no. 6, Dec. 1925, pp. 270 and 272, 1 fig. Particulars of principal features of station pumping capacity of which was 5,000,000 gal. per day; operating routine, with particular reference to method of cleaning fires.

Hand Firing. Hand Firing for Power Boilers. Power Plant Eng., vol. 30, no. 1, Jan. 1, 1926, pp. 31–36, 12 figs. Points out that personal element is more of deciding factor in fuel saving than with power stokers.

BOILER FURNACES

Cass Type. The "Cass" Sprinkler Stoker and Self-Cleaning Furnace. Iron & Coal Trades Rev., vol. 111, no. 3014, Dec. 4, 1925, pp. 918–919, 6 figs. Design and construction of stoker and furnace introduced by Thos. Cass & Co., Bolton; furnace is arranged so that each channel bar has a slow to-and-fro motion of about 3 in. in either direction, which motion is transmitted by cams from a pair of driving shafts under front of furnace, operated through a worm wheel.

Secondary Air Supply. Modern Furnaces and Secondary Air Supply. Eng. & Boiler House Rev., vol. 39, no. 6, Dec. 1925, pp. 267–268, 1 fig. Deals with method and apparatus for securing and maintaining higher average furnace temperature; use of ventilated or perforated firebrick; furnace-arch design; use of preheated air.

Temperature Determination. Boiler Furnace Temperatures with Preheated Air, J. G. Coutant. Power, vol. 63, no. 5, Feb. 2, 1926, pp. 189–190, 1 fig. Describes method and chart for determining furnace temperatures which is both theoretically and practically correct.

Wood-Waste-Burning. Special Furnaces Required for Wood Waste. Power Plant Eng., vol. 30, no. 1, Jan. 1, 1926, pp. 36–40, 5 figs. Means for handling wood waste; requirements for combustion; features of furnace and grates.

BOILER OPERATION

Fuel and Draft Control. Automatic Control of Fuel and Air to Boilers, H. M. Hammond. Power Plant Eng., vol. 29, no. 24, Dec. 15, 1925, pp. 1259–1261, 4 figs. Steam pressure shows relation of inflow and outflow of B.t.u. and controls regulate amount and proportions of fuel and air for balance.

BOILER PLANTS

Efficiency. Determining Efficiency of Boiler Plants (Die Festellung des Wirkungsgrades einer Kesselanlage), P. Wiegleb. Wärme, vol. 48, no. 23, June 1925, pp. 297–299. Discusses preparations for an acceptance test and calculations in connection with test; main conditions for rational operation of a boiler plant.

Great Britain. Vickers Boilers at Fulham. Power Engr., vol. 20, no. 237, Dec. 1925, pp. 468–470, 3 figs. New generating and boiler plant recently placed in commission at Fulham Borough electricity works; boiler plant is self-contained and comprises three 40,000-lb. units, each complete with its own economizer, forced-draft fan and Prat induced draft fan and stock.

Pulverized-Coal-Fired. Pulverized Coal to Replace Hand Firing. Power Plant Eng., vol. 29, no. 24, Dec. 15, 1925, pp. 1279–1280, 2 figs. Demand for increased economy and capacity has led Lambert Tire & Rubber Co. to build new boiler plant.

BOILERMAKING

Sulzer Shops, Switzerland. The New Sulzer Boiler Shops in Winterthur. Sulzer Tech. Rev., no. 4, 1925, pp. 9–11, 3 figs. Details of equipment of new shops having a floor area of 47,000 sq. ft.; new riveting machine can take plates up to 14 ft. 9 in. wide and boilers up to 12 ft. 6 in. in diameter; drilling and milling machines, welding.

BOILERS

Design. Boilers and Boiler Auxiliaries. Power, vol. 63, no. 1, Jan. 5, 1926, pp. 4–8, 2 figs. Air preheating and water-cooled walls prominent in furnace design; improved metals give preference to high temperatures over high pressures; present limitations and status of various auxiliaries.

Feeding Equipment, Operation of. Operation of Boiler Feeding Equipment. Power Plant Eng., vol. 30, no. 1, Jan. 1, 1926, pp. 52–59, 15 figs. Arrangements of piping and valves; operation of pumps; pump governors and feedwater regulators; priming and water level.

Fireless. Fireless Boiler Generates Steam at 1,500-lb. Pressure. Power, vol. 62, no. 26, Dec. 29, 1925, pp. 1007–1009, 2 figs. Evaporation produced by superheated steam blown through water in steel drum; hot gases come in contact with superheater and economizer tubes only, steam-generating drums being located outside of boiler setting; experimental plant successfully tried out in Vienna, Austria; 1000-kw. plant under construction and 18,000-kw. plant started.

Heat Balance. The Daily Heat Balance, W. H. Wood. Combustion, vol. 13, no. 6, Dec. 1925, pp. 351–354. Discusses introduction of recording steam-pressure gages, CO_2 recorders, etc.; advocated employment of a fuel and combustion supervisor for large steam plants whose duty would be to see that fuel is burned as economically as possible; chief preventable losses are: heat carried away in flue gases, carbon in ash pit, unburned combustible gases, unburned solid carbon deposited in boiler or carried out of stack.

High-Pressure. High-Pressure Boilers (Hochdruckkessel), Fischer und Schleip. Kruppsche Monatshefte, vol. 6, Oct. 1925, pp. 185–202, 22 figs. Discusses developments, materials used and their strength at high temperatures; seamless boiler shells of nickel steel; calculation of boilers and formulas, Hamburg standards, boiler ends.

Internal-Combustion. Another Internal Combustion Boiler. Eng. & Boiler House Rev., vol. 39, no. 5, Nov. 1925, pp. 220 and 216, 1 fig. Principles of Weir proposal, which is to burn fuel under high pressure, when products of combustion are mixed with certain proportion of water which is vaporized by heat of combustion.

Joints for Air-Leakage Prevention. Preventing Air Leakage on Cylindrical Boilers. Eng. & Boiler House Rev., vol. 39, no. 5, Nov. 1925, pp. 228 and 230, 2 figs. Describes Bramwell expansion joints for keeping front and back ends of boilers air-tight.

Patents, 1925. Boiler and Auxiliary Patents of 1925, N. Frucht. Power, vol. 63, no. 1, Jan. 5, 1926, pp. 26–29, 4 figs. Patent-office records reveal trend in boiler designs; new baffle arrangements; mercury-boiler developments; superheater and accumulator claims.

Scale Prevention. A New Process for Boiler Scale Prevention. Eng. & Boiler House Rev., vol. 39, no. 5, Nov. 1925, pp. 232–233, 2 figs. Describes filtrator apparatus, and principle upon which it works.

Strains in. Experiments on Strains in Boilers, C. E. Stromeyer. Engineer, vol. 140, no. 3650, Dec. 11, 1925, pp. 649–650, 6 figs. Measurements were carried out which throw light on nature and intensity of bending strains, which up to now have not been measured; results of tests on small locomotive portable boiler; donkey boiler dished crown plate; lap-joint bending; stresses near lap joints; shell-extension experiments. Memorandum of Manchester Steam Users' Assn.

Waste-Heat. Results of Questionnaire on Waste Heat Boilers, C. H. Wilcox. Gas Age-Rec., vol. 56, no. 22, Nov. 28, 1925, pp. 777–778. Details of statistics supplied by 22 different companies in answer to a question blank containing 17 questions.

Water-Level Gages. A New Boiler Water Level Indicator. Eng. & Boiler House Rev., vol. 39, no. 5, Nov. 1925, p. 235, 2 figs. New design, put on market by Ferguson Superheaters, Ltd., is capable of either indicating or recording or both.

[See also STEAM GENERATORS.]

BOILERS, WATER-TUBE

Tests. Test of Boilers in the Central Station of the Mines of Courrières, France. Power, vol. 63, no. 5, Feb. 2, 1926, pp. 168–170, 6 figs. General characteristics of water-tube boilers installed in 50,000-kw. plant serving a group of mines; testing boilers, and results of tests.

BORING MACHINES

Traversing Spindle. Pearn-Richards Machine with Traversing Spindle. Brit. Machine Tool Eng., vol. 3, no. 36, Nov.-Dec., 1925, pp. 343–346, 4 figs. Design and operation of improved traversing spindle machine and provision of various attachments further extending varied operations that may be performed at one setting of the work.

BRAKES

Automatic Adjuster. Gould Automatic Brake Slack Adjuster for Freight Equipment Type "F." Ry. & Locomotive Eng., vol. 38, no. 12, Dec. 1925, pp. 364–365, 3 figs. Adjuster automatically takes up wear in shoes, wheels, pins, and pin holes, keeping piston travel within approximately ½ in. of normal from application of new shoes until they are worn out.

Rail. European Hydraulic Car Retarders. Ry. Signaling, vol. 18, no. 12, Dec. 1925, pp. 466–469, 7 figs. Rail-brake installations in service on several Continental railways; movement of switches controlled automatically; invented by Dr. Froelich, railway superintendent of the German Government.

Reducing Valve for Vacuum. Reducing Valve for the Vacuum Automatic Brake. Engineer, vol. 140, no. 3650, Dec. 11, 1925, p. 645, 1 fig. New type of reducing valve made by Gresham & Craven, Manchester, Eng., for use with vacuum automatic brake being tested on railways in England and in India.

BRASS

High-Tensile. Notes on High Tensile Brasses, Thibaud. Foundry Trade Jl., vol. 32, no. 486, Dec. 10, 1925, p. 498. Practical summary of all information already collected on subject of high tensile brasses; influence of constituents; incorporation of metal additions; melting high-tensile brass; molding.

BRIQUETTING

Binders. Binders for Briquetting, with Special Reference to "Pulp Binders," C. J. Goodwin. South Wales Inst. of Engrs.—Proc., vol. 41, no. 5, Dec. 12, 1925, pp. 443–461. Details of experience with binders other than pitch, including starches, such as cassava or sago, sea-weed extract, mixed with pitch or bitumen, and sulphite liquor; production and cost of pulp binders.

C

CABLEWAYS

Aerial Tramways. Fordson Engineers "Span" Their Difficulties, J. H. Edwards. Coal Age, vol. 28, no. 26, Dec. 24, 1925, pp. 887–888, 7 figs. Methods employed by Fordson Coal Co., at Stone, Ky., of disposing of mine refuse by aerial tram; double cable is used to support aerial hanger.

Reverse Drive with Stress Equalizer. The Importance of Stress Equalization for Reverse Drives (Die Bedeutung des Spannungsausgleichs für Umkehrantriebe), O. Ohnesorge. Zeit. des Vereines deutscher Ingenieure, vol. 69, no. 52, Dec. 26, 1925, pp. 1631–1636, 14 figs. Occurrence of pulley-block stresses in rigid multiple-disk drives has been confirmed; the peculiar effect of these stresses can be recognized by use of reverse drive with stress equalizer; advantages of stress equalization for mountain railways.

CAR COUPLERS

Automatic. Mechanical Couplers for the Indian Broad-gauge Railways. Engineer, vol. 140, no. 3652, Dec. 25, 1925, p. 694, 3 figs. Describes coupler, known as Willison, in which ordinary screw coupling hangs from coupler head, and is ready for attachment of ordinary vehicle by simply lifting and throwing shackle over hook.

CARS, REFRIGERATOR

Fruit Transportation. D. L. & W. Fruit Refrigerator Cars, P. Alquist. Ry. Age, vol. 79, no. 24, Dec. 12, 1925, pp. 1099–1100, 2 figs. Special attention given to air circulation and insulation in cars built by Am. Car & Foundry Co at Perwick, Pa.; A.R.A. Standards closely adhered to.

CAST IRON

Engineering Practice and. Cast-Iron and Modern Engineering Practice, J. G. Pearce. Engineering, vol. 120, no. 3129, Dec. 18, 1925, p. 781. (Abridged.) Paper read before (Brit.) Instn. Mech. Engrs.

Graphite in. Graphite in Cast Iron. Metal Industry (Lond.), vol. 27, nos. 18 and 22, Oct. 30 and Nov. 27, 1925, pp. 411–414 and 511–513, 10 figs. Nature and influence of graphite in structure; solubility of carbon in iron and effect of other constituents; effect of mass on graphite separation and rate of cooling effects, particularly in respect to how some resulting difficulties can be overcome, as by use of low-carbon metal; photomicrographs. Nov. 27: Forging cast iron; crucible cast iron; special cases of nodular graphite.

Gray, Influence of Special Elements on. The Influence of Special Elements on Grey Cast Iron, J. W. Donaldson. Foundry Trade Jl., vol. 32, no. 489, Dec. 31, 1925, pp. 553–555 and (discussion) 555–556. Investigations of influence of manganese, chromium, nickel, tungsten, molybdenum, vanadium, copper, tin, aluminum, titanium; heat treatment of alloy cast irons; conclusions.

Growth. The Growth of Cast Iron. Metallurgist (Supp. to Engineer), Nov. 27, 1925, p. 161. Review of studies on this subject.

Pearlitic, for Diesel Castings. The Production of Diesel Castings in Pearlitic Cast Iron, A. J. Richman. Foundry Trade Jl., vol. 32, nos. 484 and 485, Nov. 26 and Dec. 3, 1925, pp. 449–451 and 471–474, 14 figs. Nov. 26: Lanz pearlitic cast iron; Thyssen-Emmel process; basic principles; superheated iron for heating molds; cast iron suitable for internal-combustion engines; inherent difficulties; melting conditions; cylinder metal; hardness and tensile strength. Dec. 3: Cylinders, cylinder cores, heads and liners; principle of runner; pistons; mold temperatures; gating; assembling molds; flywheels. See also (discussion) in no. 486, Dec. 10, 1925, pp. 496–498.

Research, Application of. Some Applications of Research to Modern Foundry Practice, J. E. Fletcher. Engineering, vol. 120, no. 3129, Dec. 18, 1925, pp. 781–783, 8 figs. Author seeks to illustrate in some detail a few examples of type of work and method of attack used in applying results of research to current foundry practice; skin defects, shrinkage and contraction; trend of future developments in cast iron. (Abridged.) Paper read before (Brit.) Instn. Mech. Engrs.

Silicon, Influence of. Practical Points from Published Papers, B. Rogers. Foundry Trade Jl., vol. 32, no. 489, Dec. 31, 1925, pp. 547–548. Sulphur prints; influence of silicon upon carbon in cast iron; Hamasumi's experiments on influence of silicon upon cast iron; whirling graphite; influence of silicon upon combined carbon; ratio of silicon to combined carbon; further experiments by Hamasumi.

CASTING

Centrifugal. Notes on the Centrifugal Casting Process with Special Reference to the Hurst-Ball Process, J. E. Hurst. Foundry Trade Jl., vol. 32, nos. 480 and 481, Oct. 29 and Nov. 5, 1925, pp. 361–365 and 381–384, 12 figs. Oct. 29: Commercial application of centrifugal casting method; axis of rotation; method of pouring; rotating mold. Nov. 5: Life of metal molds; typical defects; surface depressions and pinholes; inside surface defects; characteristic roughening of inside surface; chemical composition and other properties of molten metal; application and advantages of centrifugal casting process. Bibliography.

CASTINGS

Sand Blasting. Sandblasting Castings, H. Orr. Abrasive Industry, vol. 6, no. 12, Dec. 1925, pp. 367–370, 3 figs. Discusses methods of preparing surfaces and sand blasting; direct-pressure, suction, and gravity system; determination of velocity of air, abrasive materials, nozzles, etc.

CENTRAL STATIONS

Automatic Control. Automatic Control at Cahokia, H. T. Lange. Power Plant Eng., vol. 30, no. 2, Jan. 15, 1926, pp. 128–130, 8 figs. Most of auxiliaries at Cahokia station of Union Elec. Light & Power Co. of St. Louis, are motor-driven and equipped with automatic control.

Centralized Management. Record Trend to Centralized Management. Elec. World, vol. 87, no. 1, Jan. 2, 1926, pp. 24–28. Gives table of mergers of central-station systems during 1925, involving 560 companies.

Chicago, Ill. The Crawford Avenue Station of the Commonwealth Edison Company, J. Wolf. Combustion, vol. 13, no. 5, Nov. 1925, pp. 269–274, 10 figs. Description of superpower station which has recently been opened, and discussion of its special features.

Colfax, Pittsburgh, Pa. Recent Developments at Colfax Station, Chas. W. E. Clarke. Mech. Eng., vol. 48, no. 1, Jan. 1926, pp. 39–43, 8 figs. Results of tests of 3-A element installed in station of Duquesne Light Co., showing net heat rates of 12,750 B.t.u. per kw-hr. at 30,333 kw., 13,021 B.t.u. per kw-hr. at 22,400 kw., and 14,200 B.t.u. per kw-hr. at 15,050 kw.; boiler-room and turbine-room operating results; costs.

Columbia, Ohio. Columbia Power Station Serves Southwestern Ohio. Power Plant Eng., vol. 30, no. 3, Feb. 1, 1926, pp. 190–199, 12 figs. New plant, about 20 mi. west of Cincinnati, uses pulverized coal, tandem-compound turbines with reheat, air preheaters and other interesting equipment.

Construction, 1925. A Year of Intensive Construction. Elec. World, vol. 87, no. 1, Jan. 2, 1926, pp. 53–56. Statistical data on steam and hydro-electric generating plants under way in United States and Western Canada during 1925; total of 7381 mi. of high-tension transmission line erected during year.

Hell Gate, New York. New Boiler Equipment at the Hell Gate Power Station, New York, J. B. C. Kershaw. Engineer, vol. 140, no. 3651, Dec. 18, 1925, pp. 674–675, 6 figs. partly on p. 670. General description of station, with all details available relating to stokers and furnace design.

Parr Shoals, S. C. Parr Shoals New Steam Standby Station. South. Engr., vol. 43, no. 10, Dec. 1925, pp. 35–45, 20 figs. Details of central station on Broad River, at Parr Shoals, S. C., of Broad River Power Co.; first standby steam station in South to use pulverized fuel, economizers and designated for economic service; ultimate capacity 80,000 hp.

Statistics, 1925. 1925 a Record Year. Elec. World, vol. 87, no. 1, Jan. 2, 1926, pp. 7–10, 3 figs. Energy generated during year totaled 59,517,000,000 kw-hr.; gross revenue is estimated at $1,470,000,000; distinct trends which were established during year.

Susquehanna, Middletown, Pa. Coal Preparation and Operating Results at the Susquehanna Station, Metropolitan Power Co. Power, vol. 62, no. 26, Dec. 29, 1925, pp. 1000–1005, 10 figs. Plant designed for 200,000-kw. ultimate capacity; pulverized bituminous and river coal used as fuel; combined waste-heat and steam drier employed; tests of boiler plant show over 90 per cent efficiency.

Twin Branch, Mishawaka, Ind. Twin Branch Carries Base Load. Power Plant Eng., vol. 30, no. 2, Jan. 15, 1926, pp. 118–128, 17 figs. New plant of Am. Gas & Elec. Co., at Mishawaka, Ind., uses no circulating pumps, had hydro plant as auxiliary house generator and other interesting features; tabular data of principal equipment.

CHIMNEYS

Draft. Effect on Chimney Draft on Fuel Economy (Der Einfluss des Schornsteinzuges auf die wirschaftliche Ausnützung der Brennstoffe), Bechtold. Rauch u. Staub, vol. 15, no. 11, Nov. 1, 1925, pp. 89–92. Report of Union of German Chimney Sweepers discussing temperature of combustion, air excess, smoke and soot deposit; advantages of a standard draft just strong enough to distinguish a candle at a 2-cm. opening of ash door.

COAL

Ash. Coal Ash and Clean Coal, R. Lessing. Gas Jl., vol. 172, no. 3265, Dec. 9, 1925, pp. 650–654. Chemical and physical behavior in combustion process, fusibility of coal ash, ash as inert matter, influence of ash composition and catalytic influence of mineral constituents; hydrogenation and total conversion into oils.

Pulverized. See PULVERIZED COAL.

COAL HANDLING

Equipment. Modern Coal-Handling Equipment, E. Zeuthen. Elec. World, vol. 87, no. 2, Jan. 9, 1926, pp. 87–89, 3 figs. Designed to cut labor cost for power stations and insure continuous coal supply; describes electrical equipment used in modern station.

Manufacturing Plants. Coal-Handling Plant of the A. Borsig Machine Works in Tegel, near Berlin, Germany (Die Kohlen- und Schuttförderanlage der Maschinenfabrik A. Borsig G.m.b.H. in Tegel), A. Illemann. Zeit. des Vereines deutscher Ingenieure, vol. 69, no. 50, Dec. 12, 1925, pp. 1562–1566, 7 figs. Economic aspects of conveyor plants in machine works; describes equipment of Borsig plant; unloading plant; loading bridges, cranes, car dumpers, suspended railways; efficiency and savings effected.

Peck Carrier. Coal Handling with Overlapping Buckets, F. Dawson. Eng. & Boiler House Rev., vol. 39, no. 5, Nov. 1925, pp. 222–223, 2 figs. Describes principal features of Beck Carrier, adopted almost universally in United States.

Unloaders. New Coal Stacking and Coaling Installations (Neue Kohlenstapel- und Bekohlungsanlagen mit Heinzelmann-Entladern), Hermanns. Wärme, vol. 48, no. 43, Oct. 23, 1925, pp. 548–549, 2 figs. Describes two applications of Heinzelmann unloader; in one case, coal taken straight out of truck by vertical elevator (carried by gantry spanning the truck), is delivered onto a horizontal belt conveyor, which spans storage yard and discharges where required; installation is designed to deal with 30 tons a day; second installation is essentially the same, except that overhead horizontal conveyor discharges into bunkers above boilers, instead of dropping coal in open storage yard.

COMBUSTION

Control. Automatic Combustion Control. Eng. & Boiler House Rev., vol. 39, no. 5, Nov. 1925, pp. 213–216, 4 figs. Describes principal features of Bailey meter control as applied to recent American superpower stations.

CONDENSERS, STEAM

Air Leakage, Testing for. Better Condenser Performance Through Down Air Leakage, F. E. Murphy. Power, vol. 63, no. 5, Feb. 2, 1925, p. 183, 3 figs. Describes special shaft packing for testing turbine casing for leaks.

CONDUITS

Pressure. The Drac-Romanche Water Power Undertaking. Engineer, vol. 140, no. 3652, Dec. 25, 1925, pp. 692–693, 7 figs. partly on p. 696. Details of pressure pipe of 6-m. internal diam. constructed in connection with power station near Grenoble in French Alps; built of reinforced concrete; construction methods.

CONNECTING RODS

Milling. Milling Motor Lorry Connecting Rods. Machy. (Lond.), vol. 27, no. 692, Dec. 31, 1925, pp. 446–448, 6 figs. Complete tooling equipment for milling operations on connecting rods for motor trucks.

CONVEYORS

Factory. Conveying at Industrial Works (Massenbewegung in Industriebetrieben), v. Bezold. Chemiker-Zeitung, vol. 49, nos. 118 and 121, Oct. 1 and 8, 1925, pp. 833–834 and 855–856, 1 fig. Discusses methods and apparatus for conveying mass goods and individual goods in horizontal, vertical or inclined direction; bands, spirals, scrapers, gutters; bucket, rocking and pneumatic conveyors; construction and applications.

Mail. Postal Conveying at the German Transportation Exposition [Die postalische Fördertechnik auf der Deutschen Verkehrsausstellung (München 1925)], I. Schwaighofer. Fördertechnik u. Frachtverkehr, vol. 18, nos. 21, 22, 23, Nov. 5, 20, Dec. 5, 1925, pp. 328–333, 344–351, 358–364, 37 figs. Details of exhibits by German and Austrian post and telegraph offices, including mail-conveying plants by tube, rope, belt. Package-sorting turbines, electric post-office apparatus for letters and packages. Conveying mail bags and sacks; electric trucks, etc.

COPPER

Cold Working. The Effect of Cold-Working and Annealing on Some Physical Properties of Copper, Aluminium and Their Alloys, T. Matsuda. Tohoku Imperial Univ.—Sci. Reports, vol. 14, no. 4, Oct. 1925, pp. 343–376. Results of investigation of effect of cold-working on mechanical properties and electric resistance of copper, aluminum and their commercial alloys, followed by subsequent low-temperature annealing; effect of cold twisting; variation of electric resistance during heating of cold-drawn rods; concludes that electric resistance increases on cold deformation, whether produced by rolling, drawing or twisting; that when metals are annealed resistance decreases in two steps. (In Japanese.)

CORROSION

Iron and Steel. Chemical Composition of Rust (Die chemische Konstitution des Rostes), Stumper. Feuerungstechnik, vol. 14, no. 2, Oct. 15, 1925, pp. 16–20, 1 fig. Shows that there is no definite chemical formula for rust, it is a mixture of ferrous and ferric oxide and probably colloidochemically combined water, ferrous oxide being formed as an intermediary oxidation product of iron.

Metallic. Metallic Corrosion, W. S. Patterson. Inst. Marine Engrs.—Trans., vol. 37, Nov. 1925, pp. 437–447. Discusses modern theories of mechanism of corrosion, especially electrochemical theory and its primary value in study of corrosion; type of corrosion which persists in acid and in neutral media, water line corrosion; effect of corrosion deposits and debris.

COST ACCOUNTING

Factory. Business Methods, J. Craig. Can. Mfrs., vol. 45, no. 12, Dec. 1925, pp. 15–17. Cost accounting as aid to factory production and executive control.

COTTON MILLS

Operation. Some Common Faults in Cotton Goods, F. Summers. Textile Inst.—Jl., vol. 16, no. 2, Nov. 1925, pp. T323–T337, 4 figs. Irregular character of the raw material, showing that some defects are outside control of spinning; typical classes of faults, and microscopic method of getting at them, including neps, yarn discolorations and barring due to irregularity and mechanical faults; faults due to mercerization.

CRANES

Floating. 300-Ton Floating Crane for Handling Concrete Blocks. Engineering, vol. 120, no. 3130, Dec. 25, 1925, pp. 797–798, 9 figs. partly on supp. plate. Details of 300-ton crane built by N. V. Internationale Scheepsbouw, Maatschappj de Maas, Holland, to be used for harbor work in Spain.

Standardization. The Standardization of Crane Essentials, E. C. Fiegehen. Engineer, vol. 140, no. 3649, Dec. 4, 1925, pp. 600–602, 1 fig. Summary of chief objects which might be attained by uniformity in practice proposed, namely, (1) to secure uniform basis for tendering; (2) to increase efficiency of crane inspection and testing; (3) to protect public against dangerous

construction and conditions; (4) to secure undoubted economies resulting from greater uniformity in demand and manufacture; discusses technical aspects of standardization.

Underhung Traveling Jib. Underhung Travelling Jib Crane. Engineer, vol. 140, no. 3650, Dec. 11, 1925, p. 648, 2 figs. One-ton, four-motor, overhead electric traveling cranes with underhung revolving jibs, constructed by Vaughan Crane Co., Manchester, Eng., for Kilindini Harbor, on Uganda Ry.

CUPOLAS

Successful Practice. Successful Cupola Practice. Metal Industry (Lond.), vol. 27, no. 24, Dec. 11, 1925, pp. 561–562. In author's opinion, state of cupola practice at present time is below that which would be expected from the considerable amount that has been written on subject; he believes this is due more to impractical nature of advice than to disinterestedness of foundryman to act upon it; describes chief essentials to successful cupola practice.

Tuyeres. The Tuyere Problem. Metal Industry (Lond.), vol. 27, no. 23, Dec. 4, 1925, pp. 539–540. Author considers that there is much needless controversy about shape of tuyeres; within reasonable limits, tuyere shape is relatively unimportant compared with other items in cupola practice; discusses question as to whether more than one row of tuyeres should be used, and points out that, in few cases where this might be desirable, extra rows should not be designed similarly to first.

Tuyere Arrangement. Metal Industry (Lond.), vol. 27, no. 25, Dec. 18, 1925, pp. 583–584, 1 fig. Gives experimental evidence to show that use of two rows of tuyeres can give very definite advantages over use of one row of tuyeres of same total area.

CUTTING METALS

Butane Torches. The Production of Butane and the Butane Torch. Natural Gas, vol. 6, no. 9, Sept. 1925, pp. 12, 2 figs. Production of butane and its application to cutting metals with a blow torch, especially designed to use butane.

CUTTING TOOLS

Cutting Temperature, Measurement of. Measuring the Cutting Temperature in the Cutting of Low Carbon Steel (Die Messung der Schneidentemperatur beim Abdrehen von Flusseisen), Gottwein. Maschinenbau, vol. 4, no. 23, Nov. 19, 1925, pp. 1129–1135, 30 figs. Discusses necessity for knowing the cutting temperature; measuring it by means of thermoelectric current for various feeds, speeds, depth of cut, and developing calibrating curves from data obtained.

CYLINDERS

Bore Finishing. Cylinder Bore Finishing, Rob. W. Adams. Am. Mach., vol. 64, no. 2, Jan. 14, 1926, pp. 51–56. Symposium of practices in ten leading automobile manufacturing plants.

Drawn. The Production of Deep Drawn Cylinders, W. J. Guyer. Forging—Stamping—Heat Treating, vol. 11, no. 12, Dec. 1925, pp. 427–429, 3 figs. Discusses importance of selecting proper stock, lubrication, annealing and pickling; life and wearing properties of die steels.

D

DIE CASTING

Process and Machines. Die Casting, N. F. Budgen. Engineering, vol. 120, no. 3129, Dec. 18, 1925, pp. 777–778. Advantages of die-casting process; disadvantages of die castings; die-casting machines, their design and working; dies for die casting; metals and alloys for die castings.

DIES

Steering-Wheel Spiders. Dies for Steering-Wheel Spiders, Jas. M. Acklin. Machy. (N. Y.), vol. 32, nos. 4 and 5, Dec. 1925, and Jan. 1926, pp. 283–285, 9 figs. and 388–390, 7 figs. Construction of dies used in stamping hub for steel spiders of automobile steering wheels.

DIESEL ENGINES

Atlas-Imperial. Atlas-Imperial Diesel Engines. Diesel & Oil Engine Jl., vol. 1, no. 1, Nov., 1925, pp. 13–15, 2 figs. Design and operation of four-stroke-cycle engines with mechanical injection.

Bessemer. The Bessemer Diesel Engine. Diesel & Oil Engine Jl., vol. 1, no. 1, Nov. 1925, pp. 16–18, 3 figs. Details of design and construction; starting engine from cold; comparative cost of fuel for oil, gas, and steam engines, and electric motors.

Developments. Growth of the Diesel Engine Field, R. C. Paul. Power Plant Eng., vol. 29, no. 24, Dec. 15, 1925, pp. 1277–1278, 1 fig. Building units of both larger and smaller sizes has opened new fields for Diesel engines during past year.

Sulzer. Sulzer Diesel Engines. Diesel & Oil Engine Jl., vol. 1, no. 1, Nov. 1925, pp. 7–12, 6 figs. Compares efficiency of various types of power plants and gives details of design of engines built by the Busch-Sulzer Bros. Diesel Engine Co.

The 1000 K.W. Sulzer Diesel Engine. Sulzer Tech. Rev., no. 4, 1925, pp. 12–14, 17 figs. Various types built for electric power station, street-car plant, blast-furnace and steel works, cotton mills, mines, radio station; details of designs and tests.

Western-Enterprise. Western-Enterprise Diesel Engine. Diesel & Oil Engine Jl., vol. 1, no. 1, Nov. 1925, pp. 19–21, 3 figs. Design and construction of four-stroke cycle engine, employing mechanical injection, built to Lloyd's and American Bureau of Shipping Requirements.

DRILLING

Differential Housing. Drilling a Differential Housing. Automobile Engr., vol. 15, no. 210, Dec. 1925, pp. 459–460, 3 figs. Multiple fixture for use on 2-spindle machine.

DRILLING MACHINES

Automatic Feed. Automatic Feed on Sensitive Drilling Machines. Machy. (Lond.), vol. 27, no. 692, Dec. 31, 1925, pp. 411–445, 13 figs. Self-starting and quick-starting mechanisms.

Radial, Transmission and Control. Transmission and Control on Radial Drilling Machines. Machy. (Lond.), vol. 26, nos. 653, 671 and 678, Apr. 2, Aug. 6, and Sept. 24, 1925, pp. 1–5, 580–584 and 809–813, 35 figs. Deals with methods of conveying power to spindles of radial drilling machines and arrangements for controlling positions and effecting locking.

E

ECONOMIZERS

Operation and Maintenance. Economizer Operation and Maintenance. Power Plant Engr., vol. 30, no. 1, Jan. 1, 1926, pp. 62–64, 5 figs. Cleanliness of tubes and keeping of water and gas at proper temperatures are of great importance; soot removed by scraping; occasional explosions due to vapor pressure; cast-iron or steel tubes may be used.

Types. General Types of Fuel Economizers, W. F. Keenan, Jr. Power Plant Eng., vol. 30, no. 1, Jan. 1, 1926, pp. 60–62. Higher steam pressures and temperatures have created increased demand for economizers.

EDUCATION, ENGINEERING

Graduates. A Study of Engineering Graduates and Former Students, Non-Graduates. Jl. Eng. Education, vol. 16, no. 4, Dec. 1925, pp. 259–268. Details of report based on questionnaire replies as to occupation and earnings of graduates and their opinion on engineering education.

Teaching Personnel. A Study of Teaching Personnel of the Colleges of Engineering. Jl. Eng. Education, vol. 16, no. 4, Dec. 1925, pp. 299–311, 2 figs. Details of report based on circular inquiry concluding that real problem is to secure right type of teachers for engineering faculties, and that this constitutes a major problem in engineering education.

EDUCATION, INDUSTRIAL

Baltimore Plan. The Baltimore Plan of Industrial Education, E. B. Luce. Am. Gas Jl., vol. 123, no. 26, Nov. 28, 1925, pp. 583–584 and 598, 3 figs. Describes plan as developed and applied by Consolidated Gas, Electric Light & Power Co. of Baltimore.

Gas Engineers. Technical Training within the Gas Industry, W. Hole. Gas. Jl., vol. 171, no. 3253, Sept. 16, 1925, pp. 669–672. Discusses new scheme of education comprising training and certification of gas-fitters, training and certification of those not taking professional courses, and training and certification of gas engineers.

ELASTICITY

Modulus of. Relations between Young's Modulus and Other Physical Quantities, J. P. Andrews. Lond., Edinburgh & Dublin Philosophical Mag. & Jl. of Sci., vol. 50, no. 298, Oct. 1925, pp. 665–674, 4 figs. Discusses attempts made to connect Young's modulus with other physical constants and shown that among those only that of Clemens Schaefer between temperature coefficients and melting point is borne out by experiments.

ELECTRIC FURNACES

Brass and Bronze. The S. B. N. Simplex Electric Furnace (Four électrique S.B.N. "Simplex"). Jl. du Four Electrique, vol. 34, no. 16, Nov. 15, 1925, pp. 219–222, 2 figs. Details of design and operation of the Nolly furnace, of special interest for brass and bronze foundries; may be worked by a.c. one, two or three phase, or even by d.c.; has two water-cooled electrodes of large cross section.

Steel. Electric Furnace Steel, F. T. Sisco. Am. Soc. Steel Treating—Trans., vol. 8, no. 6, Dec. 1925, pp. 748–770 and (discussion) 771–781, 1 fig. Basic electric process is used for manufacture of high-grade alloy and tool-steel ingots, occasionally for castings; acid process is used principally for castings; advantages of electric process are: (1) extreme flexibility and (2) high-quality steels produced in tonnage lots; direct arc furnace with non-conducting hearth is used almost exclusively in United States; charging, melting, chemistry of oxidation, control of oxidation in melting; slagging off and carburization; deoxidation period, deoxidizing slag; deoxidation of slag and metal; desulphurization and degasification.

Tilting-Type. New Tilting Type Electric Furnace. West. Machy. World, vol. 16, no. 11, Nov. 1925, pp. 464–465, 4 figs. Describes Kay patented furnace; body is mounted to rotate on substantially horizontal axis with spout at each end for pouring molten metal.

Vacuum. Thin Graphite-Tube Vacuum-Electric Furnace. Engineering, vol. 121, no. 3132, Jan. 8, 1926, pp. 42–43, 4 figs. Details of improved furnace, which retains characteristic features of Ruff furnace; used for study of high-temperature reactions at East London College.

ELECTRIC LOCOMOTIVES

Norfolk & Western Ry. New Locomotives for the Norfolk and Western Railway. Engineer, vol. 141, no. 3656, Jan. 22, 1926, pp. 96–98, 10 figs. partly on supp. plate. Details of engines of 2-unit type with two parts normally permanently coupled, but capable of being separated for repairs, wheel arrangement being 2–8–2 + 2–8–2.

Switching. The 1 C Type Electric Shunting Locomotives of the Swiss Federal Railways. Brown Boveri Rev., vol. 12, no. 11, Nov. 1925, pp. 223–232, 13 figs. Design and operation of Swiss Federal Railways locomotives traveling on average of 104 km. per day; electric equipment complying with A.I.E.E. standards for stationary plant; comparative tests of steam and electric switching locomotives.

ELECTRIC WELDING, ARC

Practice and Inspection. Arc Welding Practice and Inspection, A. M. Candy. Am. Mach., vol. 64, no. 2, Jan. 14, 1926, pp. 43–45, 9 figs. Field in metal and industries; importance of standardized method and training; tests of arc-deposited metal; inspection methods.

ELEVATORS

Machining of Units. Making Elevator Units in the Otis Plant, F. W. Curtis. Am. Mach., vol. 63, nos. 26 and 27, Dec. 24 and 31, 1925, pp. 999–1002 and 1039–1042, 19 figs. Dec. 24: Method of machining sheaves; milling magnet-frame covers; drilling and planing operations; milling and boring gear cases. Dec. 31: Type of trunnion drill jig used for various parts; procedure followed in producing laminations; details of dies used; special burring machine.

EMPLOYMENT MANAGEMENT

Absenteeism. Controlling Absenteeism in Factories, E. J. Clary. Can. Mfr., vol. 45, no. 10, Oct. 1925, pp. 18–19. Gives suggestions and remedies to secure regular attendance of employees.

ENERGY

Forms and Classes. Energy, A. M. Boyce. Instn. Elec. Engrs.—Jl., vol. 64, no. 348, Dec. 1925, pp. 42–44. Discusses different forms of energy, and points out that energy can be divided into two classes, viz., potential and kinetic energy.

ENGINEERS

Civilization and. The Engineer and Civilization, W. F. Durand. Mech. Eng., vol. 48, no. 1, Jan. 1926, pp. 1–5 and 66. Notes on beginnings of material civilization; arrow-head maker as prototype of industrialist and engineer; primitive utilization of mechanical laws; great antiquity of engineering profession; modern material civilization a product of the engineering guild; how engineer may best serve cause of advancing civilization; part engineering societies have played in developments signalizing last half-century; duty of engineer as regards conservation of natural resources; renewal of personnel in engineering profession through technical education; engineering method and its application to public questions.

EVAPORATION

Water. On the Influence of Thin Surface Films on the Evaporation of Water, E. K. Rideal. Jl. of Physical Chem., vol. 29, no. 12, Dec. 1925, pp. 1585–1588, 1 fig. Rates of evaporation of water and of water covered with unimolecular films of various fatty acids; the latter are found to be much slower than from a clean water surface.

EVAPORATORS

Problems in Use of. Technical Notes on Evaporators, H. Seymour. Indus. Chemist, vol. 1, no. 5, pp. 254–258, 8 figs. Discusses problems that arise in use of evaporators.

F

FANS

Centrifugal, Motor Drives for. Motor Drives for Centrifugal Fans and Blowers, G. Fox. Power Plant Eng., vol. 30, no. 2, Jan. 15, 1926, pp. 141–144, 6 figs. Selection of motors for driving centrifugal fans requires close study of fan characteristics.

FLIGHT

Gliding. The Flapping Flight of Birds, G. T. Walker. Roy. Aeronautical Soc. Jl., vol. 29, no. 179, Nov. 1925, pp. 590–594, 2 figs. Discusses question of what would happen if flying machines were fitted with wings of standard section and these were flapped in a rhythmical manner, and gives conclusions reached from an approximate numerical analysis of flight of a rook based on measured properties of airfoils.

FLOW OF AIR

Motion of Bubble in Water. Motion of Air Bubble Rising in Water, O. Miyagi. Tohoku Imperial Univ.—Technology Reports, vol. 5, no. 3, 1925, pp. 1–33, 16 figs. Results of experiments to establish path and velocity of air bubbles through water; method of making bubbles; description of apparatus used; concludes that bubbles trace a helical course in thin upward motion, a broken line keeping its major axis always perpendicular to its course.

FLOW OF FLUIDS

Measurement. Measurement of the Rate of Flow of Fluids by the Rotameter, W. H. Simmons and F. C. Sutton. Indus. Chemist, vol. 1, no. 10, Nov. 1925, pp. 473–474, 3 figs. Describes flow meter known as Rotameter, which consists essentially of a vertical transparent tube with bore tapering towards lower end; some industrial processes in which Rotameters are being used.

Turbulence. The Problem of Turbulent Flow and

Allied Problems (Das Turbulenzproblem und verwandte Fragen), L. Schiller. Physikalische Zeit., vol. 26, no. 16, Sept. 17, 1925, pp. 566–595, 15 figs. Summarizes research work done including origin of turbulence; Reynolds law of similitude, determination of upper and lower critical number; investigation by measuring pressures of liquid and gases; law for resistance of flow in tubes; examination of turbulent flow, distribution of velocity.

FLOW OF LIQUIDS

Turbulence. The Problem of Turbulent Flow in Straight Cicular Tubes (Das Turbulenzproblem für das gerade Kreisrohr), H. Lorenz. Physikalische Zeitschrift, vol. 26, no. 16, Sept. 17, 1925, pp. 557–563, 8 figs. On assumption that in case of turbulent flow the stream consists of a core with equal average values of velocity and an edge layer with a much more rapid increase in velocity than the parallel layers, both of which completely occupy the tube, an operation is deduced for the entire phenomenon, containing only coefficient of roughness of tube and viscosity of liquid, which gives satisfactory results over a large range.

FLUE-GAS ANALYSIS

CO Determination. Determining Carbon Monoxide in Flue Gas by Iodine Pentoxide, J. F. Anthes. Gas Age Rec., vol. 56, nos. 22 and 23, Nov. 28 and Dec. 5, 1925, pp. 769–770 and 809–810, 1 fig. Details of method and apparatus for determining carbon monoxide as followed by the laboratory of Brooklyn Union Gas Co. Determination of CO by iodine penoxide; potassium iodide; preparation of starch solution; preparation of 0.001 N sodium thiosulphate and 0.001 N potassium dichromate.

Methods. Controlling Firing by Analysis of Gaseous Combustion Residue (Le contrôle de la chauffe par l'analyse des résidus gazeux de la combustion), R. Caillol. Technique Moderne, vol. 18, no. 1, Jan. 1, 1926, pp. 13–19, 11 figs. Discusses methods and apparatus for analysis, premiums based on analysis, determination of these premiums.

FLYING BOATS

Design. Recent Progress in Flying Boat Design, O. E. Simmonds. Roy. Aeronautical Soc.—Jl., vol. 29, no. 180, Dec. 1925, pp. 634–647, 7 figs. Marine and aeronautical functions of flying boats; relation of design and static trim, hump resistance, steady running, cleanliness; duralumin and other materials used; airfoil characteristics and reduction of parasite drag, etc.

Kingston. The "Kingston" Metal-Hull Flying Boat. Flight, vol. 17, no. 49, Dec. 3, 1925, pp. 791–793, 6 figs. Design and operation of English Electric Co.'s flying boat, Kingston, a five-seater reconnaissance boat fitted with two Napier "Lion" engines, constructed for British Air Ministry, the top plane having a span of 85½ feet.

FOREMEN

Training. Products and By-Products of Foremen's Conferences, Franklin T. Jones. Soc. Automotive Engrs.—Jl., vol. 18, no. 1, Jan. 1926, pp. 60–66, 5 figs. Technique of introducing, conducting and auditing foreman training; refers to four main sources of information from which liberal quotations are made and commented upon; actual methods used and results from foreman training.

FORGE SHOPS

Fuel Oil and Storage. Furnace Fuels and Oil Storage, C. C. Hermann. Machy. (N. Y.), vol. 32, no. 5, Jan. 1926, pp. 385–387, 3 figs. Fuel-oil system for small plant; oil-pipe intakes; oil-pressure control; atomizing system; oil-storage tanks.

FORGING

Machine Dies. Pointers on Forging Machine Dies, Ry. Mech. Engr., vol. 99, no. 12, Dec. 1925, pp. 783–787, 9 figs. Die design and construction; coöperation between forge shop and tool room desirable. (Abstract.) Report of Committee presented before Am. Ry. Tool Foremen's Assn.

Machines. Universal Forging Machine. Engineering, vol. 120, no. 3129, Dec. 18, 1925, pp. 768–769, 7 figs. Consists essentially of mechanical press with connecting rod of variable length; this combination makes it possible to forge work of any desired thickness by series of quick squeezes, effect coming between blows of hammer and prolonged pressure of press; manufactured by B. and S. Massey, Manchester, Eng.

Railway Shops. Forge Work in a Railroad Shop, F. A. Stanley. Am. Mach., vol. 64, no. 1, Jan. 7, 1926, pp. 5–7, 10 figs. Tools and methods used in forging bolts of various types, staybolt bushings and boiler checks; bending hooks for wrecking chains.

FOUNDRIES

Methods and Equipment, 1925. Foundrymen Refine Equipment and Methods in 1925, D. M. Avey. Iron Trade Rev., vol. 78, no. 1, Jan. 7, 1926, pp. 23–24. Conditioning, handling and conservation of sand have engaged much attention; advance in permanent-mold casting practice; development of oil-cooled molding machine; lengthening life of mold; progress in die-mold or pressure-type casting machines; simplification of high-frequency induction-type electric furnaces; other improvements.

Research, Applications of. Some Applications of Research to Modern Foundry Practice, J. E. Fletcher. Engineer, vol. 140, no. 3652, Dec. 25, 1925, pp. 703–704, 6 figs. Author seeks to illustrate a few examples of type of work and method of attack used in applying results of research to current foundry practice. Paper read before Instn. Mech. Engrs.

Testing of Materials. Physical Testing of Foundry Materials, J. S. G. Primrose. Foundry Trade Jl., vol. 32, no. 487, Dec. 17, 1925, p. 506. Brief review of paper read before Lancashire Junior Section of Inst. Brit. Foundrymen; explains differences between proof tests, such as are applied to finished article, and specification tests employing test bars or coupons.

FOUNDRY EQUIPMENT

Mechanical Sand-Handling. Reducing the Cost of Production in Iron, Steel, Malleable and Brass Foundries, R. H. Heisserman. West. Machy. World, vol. 16, no. 10, Oct. 1925, pp. 418–419. Notes on substitution of mechanical handling for manual labor; sand-handling machinery; advantages of mechanical sand conditioning.

Sand Mixer. "Simpson" Intensive Foundry Mixer. Foundry Trade Jl., vol. 32, no. 487, Dec. 17, 1925, p. 520, 1 fig. Details of sand mixer, which is of muller type with automatic discharge.

FRICTION DRIVE

Efficiency. Starting and Stopping Losses in Friction Drives (Ueber An- und Auslaufverluste bei Reibtrieben), H. Kohn. Maschinenbau, vol. 4, no. 23, Nov. 19, 1925, pp. 1136–1138, 2 figs. Shows that friction drives reach a maximum efficiency of 50 per cent; for given dynamic conditions it is considerably less.

FUELS

Developments, 1925. Fuels and Combustion. Power, vol. 63, no. 1, Jan. 5, 1926, pp. 8–12. Coal, oil and other fuels, development in stoker field, trend in pulverized-coal burning and status of low-temperature carbonization of coal with by-product recovery.

Smokeless. Glasgow and Solid Smokeless Fuel. Indus. Chemist, vol. 1, no. 10, Nov. 1925, pp. 481–488, 12 figs. Description of Maclaurin plant at Dalmarnock Gas Works, Glasgow, and methods employed.

Smokeless Solid Fuel Conference, W. E. Davies. Gas. Jl., vol. 172, no. 3266, Dec. 16, 1925, pp. 723–724. Discusses coal-ash content, plasticity and coking, physical and chemical characteristics of coke, combustibility and reactivity test, principles of carbonization.

Testing Plant. Sensible Heat Distillation. Gas Jl., vol. 172, no. 3265, Dec. 9, 1925, pp. 654–656, 2 figs. Describes plant of Sensible Heat Distillation, Ltd., used as demonstration unit for mixing various kinds of carbonaceous material, from caking and non-caking coals and lignites to town sewage.

[See also COAL; OIL FUEL; PULVERIZED COAL.]

FURNACES

Iron-Melting. The New Wüst Furnace for Refining Special Cast Iron, Th. Klingenstein. Foundry Trade Jl., vol. 32, no. 486, Dec. 10, 1925, pp. 487–490, 14 figs. Details of reverberatory-cupola furnace fired with oil and built according to Wüst patent.

Protecting Metal Parts from Oxidation. Protecting Furnace Metal Parts from Oxidation, H. E. Weightman. Power Plant Eng., vol. 29, no. 24, Dec. 15, 1925, pp. 1276–1277. Process developed by author for treating metal parts, which consists in treating metals with slip made of aluminum-iron-titanium mixture with sodium-metasilicate; no spraying apparatus is needed.

FURNACES, HEATING

Reheating. Annealing and Tempering Furnaces (Heiz- und Härteöfen), J. Wenz. Maschinenbau, vol. 4, no. 22, Nov. 5, 1925, pp. 1092–1094, 7 figs. Discusses design of furnaces operated with power gas and air gas to insure complete envelopment by gases of product to be heated in order to secure uniform heating.

G

GAGES

Motor-Truck Parts. How Motor-Truck Parts Are Gaged, F. H. Colvin. Am. Mach., vol. 63, no. 27, Dec. 31, 1925, pp. 1047–1049, 6 figs. Typical examples of gages and methods used in manufacture by Gen. Motor Truck Co. at Pontiac plant.

Pressure. An Electrical Method for Measuring Small Fluid Pressures, H. A. Thomas. Engineer, vol. 141, no. 3656, Jan. 22, 1926, pp. 88–89, 11 figs. Describes pressure gage developed by author in consultation with L. F. G. Simmonds; details of apparatus and calibration.

GAS ENGINES

Blast-Furnace Plant. Cause of Wear of Internal Parts of Gas Engines of Blast Furnaces (Les causes d'usure des parties internes des moteurs à gaz de hauts fourneaux), P. Martinet. Technique Moderne, vol. 17, no. 23, Dec. 1, 1925, pp. 765–768. Discusses wear of friction parts of mechanisms subjected to high combustion temperatures, such as pistons and cylinder lining; action of high temperatures, and of lubricating frictional parts.

Thermodynamic Analysis. A Thermodynamic Analysis of Gas Engine Tests, C. Z. Rosecrans and G. T. Felbeck. Univ. Ill. Bul., vol. 22, no. 50, Aug. 10, 1925, pp. 9–95, 27 figs. Results of investigation, developing method for calculating ideal adiabatic Otto cycle which gives results differing from actual cycle by means which can be accounted for by the various engine losses; also method for estimating progress of explosive reaction during expansion stroke, and for determining time at which reaction is practically complete.

GAS PRODUCERS

Design and Types. The Influence of Mechanical Design on the Fuel in Gas Producers (Die mechanische Beeinflussung des Brennstoffes im Gaserzeuger), H. R. Trenkler. Zeit. des Vereines deutscher Ingenieure, vol. 69, no. 50, Dec. 12, 1925, pp. 1549–1556, 37 figs. Chemical principles underlying gasification of fuel; historical development of gas-producer types and influence of design on combustion process; mechanical principles of different types; revolving plates, revolving shafts, revolving grates; conclusions.

GAS TURBINES

Wet. Wet Gas Turbines (Nasse Gasturbinen), G. Stauber. Stahl u. Eisen, vol. 45, no. 48, Nov. 26, 1925, pp. 1937–1958, 48 figs. Review of author's work and reasons which led him to favor gas turbines; describes principle and working of both dry and wet gas turbines; types of wet turbines; form developed by author and its comparison with other designs.

GASOLINE ENGINES

Exhaust-Gas Analyses. Chemical Equilibrium in Gases Exhausted by Gasoline Engines, W. G. Lovell and T. A. Boyd. Indus. & Eng. Chem., vol. 17, no. 12, Dec. 1925, pp. 1216–1219, 4 figs. With purpose of getting further knowledge of combustion reaction, which occurs so speedily in gasoline engines, authors have closely examined number of exhaust-gas analyses with interesting results, as outlined.

GRINDING MACHINES

Internal. Rivett Motor-Driven Internal Grinder No. 104. Am. Mach., vol. 63, no. 26, Dec. 24, 1925, pp. 1027–1028, 2 figs. For grinding small and accurate holes on production basis; machine is driven by two independent motors.

Roll. Large Roll Grinding Machine. Iron Age, vol. 116, no. 27, Dec. 31, 1925, p. 1805, 2 figs. Equipment for Carnegie Steel Co.'s Munhall plant has capacity for work 54 in. in diam. and 21 ft. long; four driving motors used.

GEARS

Ground. Characteristics and Use of Ground Gears H. F. L. Orcutt. Engineering, vol. 120, no. 3126, Nov. 27, 1925, pp. 691–694, 2 figs.; also Engineer, vol. 140, nos. 3648 and 3649, Nov. 27 and Dec. 4, 1925, pp. 589–591 and 618–619, 4 figs. Characteristics, use and research. (Abridged.) Paper read before Instn. Mech. Engrs.

Idler, Bearing Loads on. Bearing Loads on Idler Gears, F. W. Halliwell. Machy. (Lond.), vol. 27, no. 692, Dec. 31, 1925, pp. 461–462, 3 figs. Shows that reduction of 50 per cent or more in load can often be achieved by transposing idler gear from one side to other.

Internal. Internal Gears, H. Walker. Machy. (Lond.), vol. 27, no. 692, Dec. 31, 1925, pp. 455–457, 5 figs. Nature of internal interference; presents example showing that it is possible to obtain a 100 to 102 ratio without interference.

Normal Pitch. Normal Pitch the Index of Gear Performance, G. M. Eaton. Mech. Eng., vol. 48, no. 1, Jan. 1926, pp. 27–32, 13 figs. Brings out certain departures from previously accepted practice which are useful in manufacture of heavy involute gearing, as they ease performance during breaking-in stage of operation; shows that material improvement in performance may be secured by adopting proper relation between normal pitches of driving and driven gears, measured at point of tooth engagement; outlines development of normal-pitch indicators.

Spur. An Investigation of the Efficiency and Durability of Spur Gears, C. W. Ham and J. W. Huckert. Univ. Ill. Bul., vol. 22, no. 47, July 20, 1925, 94 pp., 42 figs. Investigation to determine reliable information on the efficiency of spur gearing, and data on change and rate of change in profiles of spur-gear teeth subjected to wear; concludes that efficiency of unhardened gears is practically independent of quantity of oil used for lubrication providing the quantity is sufficient to prevent cutting; unhardened steel pinion teeth quickly wear to outlines other than true involutes, regardless of load, speed, and lubrication; after this occurs wear practically ceases or is greatly retarded under ordinary operating conditions. Bibliography.

Teeth, Involute. Rolling and Sliding Contact in Involute Teeth, J. Cryer. Machy. (Lond.), vol. 27, no. 688, Dec. 3, 1925, pp. 289–290, 9 figs. Graphical treatment.

Teeth, Wear Experiments. Some Comparative Wear Experiments on Cast-Iron Gear Teeth, G. H. Marx, L. E. Cutter and E. M. Green. Mech. Eng., vol. 48, no. 1, Jan. 1926, pp. 33–36, 8 figs. Report of experiments made in laboratories of mechanical engineering department at Stanford Univ.

Testing. Testing Spur and Helical Gears or Cutters. Machy. (N. Y.), vol. 32, no. 5, Jan. 1926, pp. 382–383, 4 figs. Describes two machines used in tool room of Maxwell Motor Corp., Detroit, Mich., for determining accuracy of spur and helical gears and gear-shaper cutters; how test is made; using machine as comparator; checking spacing and concentricity of teeth; using optical micrometer.

Worm. Worm Gearing—Its Evolution and Manufacture, H. E. Merritt. Machy. (Lond.), vol. 26, nos. 675 and 676, Sept. 3 and 10, 1925, pp. 708–711 and 737–742, 24 figs. Features in practice of David Brown & Sons (Huddersfield). Sept. 3: Worm-gear materials. Sept. 10: Manufacture of worm; production of worm wheels.

GRINDING

Methods. Modern Grinding Operations at the Otis Plant, F. W. Curtis. Am. Mach., vol. 64, no. 4, Jan. 28, 1926, pp. 157–161, 13 figs. Machines used for grinding large work; fixture for grinding stator frames; grinding potential switch parts; grinding and inspecting worms.

GRINDING MACHINES

Large-Bore. Hutto Large-Bore Grinders. Am. Mach., vol. 64, no. 2, Jan. 14, 1926, p. 75, 2 figs.

Machine for wet grinding large-bore cylinders, of double-end or tandem type.

H

HEAT CONDUCTIVITY

Calculation. Equation of Conduction of Heat, M. C. Gray. Roy. Soc. Edinburgh—Proc., vol. 45, part 3, 1925, pp. 230–244. Discusses differential equation of conduction of heat in three-dimensional space and its various solutions, including Forsyth's and series solution; solution of equation for 2 dimensions, integral-equations solution, Fourier's solution, etc.

HEAT TRANSMISSION

Air to Tubes. Heat Transmission from Flowing Air to Tubes and Clusters of Tubes, in Cross Currents (Wärmeübergang von strömender Luft an Röhre und Röhrenbündel im Kreuzstrom), H. Reiher. Forschungsarbeiten, no. 269, 1925, pp. 1–85, 55 figs. Results of experiments to determine the coefficient of heat transmission between hot air and tubes under artificial conversion, tubes being arranged in straight rows or staggered and water passing through them. See also Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 2, Jan. 9, 1926, pp. 47–52, 13 figs.

Cooling Equations. Calculating Cooling Equations (Calcul des équations de refroidissement), E. Eichmann. Chaleur & Industrie, vol. 6, no. 67, Nov. 1925, pp. 513–517, 4 figs. Discusses law of heat transmission and resulting equations for cooling of a body; exchange of temperature in three conductors in direct contact; calculates coefficients.

HEATING, GAS

Efficiency. Relation between Heating Value of Gas and Its Usefulness to the Consumer, E. R. Weaver. U. S. Bur. of Standards—Technologic Papers, no. 290, July 21, 1925, pp. 347–463, 51 figs. Critical review of available data regarding relative usefulness of gases of different heating value, confined almost exclusively to facts expressed in definite figures; direct determination of useful facts obtained by burning gas in various appliances, and statistics regarding relative amount of gas used before and after changes of heating value, etc.

HEATING, HOT-WATER

Ford Motor Co. Forced Hot Water Systems Heats Ford's Twin Cities Plant, E. H. Whittemore. Am. Soc. Heat. & Vent. Engrs.—Jl., vol. 31, no. 12, Dec. 1925, pp. 533–540, 4 figs. Design and operation of system of forced hot-water circulation for manufacturing and assembly building, oil house, steam power plant, hydroelectric plant, etc.; equipment, pumps, pipe design, heat losses, etc.

HEATING, STEAM

Central. Development of Public Central Heating Plants (Entwicklung des öffentlichen Fernheiz-Betriebes), L. Kuhberg. Deutsche Bauzeitung, vol. 59, no. 83, Oct. 17, 1925, pp. 161–166, 10 figs. Describes plants in Braunschweig, Barmen, Frankfurt, Schwerin, and other towns in Germany; results of operations, use of waste steam, etc.

District Heating Rates for Various Conditions. Power Plant Eng., vol. 30, no. 2, Jan. 15, 1926, pp. 155–157. Brief résumé of rates of several companies, distributing both steam and hot water, may serve as guide for district-heating engineers.

Large Enclosed Spaces. Progress in Heating, Especially Large Enclosed Spaces (Fortschritte auf dem Gebiete der Raumheizung, insbesondere der Grossraumheizung), A. Neuburger. Dinglers Polytechnisches Jl., vol. 106, no. 19, Oct. 1925, pp. 219–222, 4 figs. Design and construction of Schilde air heater "Thermon," units of which can be distributed in any space as required; each unit can be operated individually, and consists of a heating and a ventilating part.

Vacuum. Vacuum Pump Heating Systems, R. H. Anderegg and M. W. Ehrlich. Domestic Eng. (Chicago), vol. 112, nos. 5, 6, 7 and 8, Aug. 1, 8, 15 and 22, 1925, pp. 22–24; 18–20; 33, 35 and 37; and 20–22, 22 figs. Aug. 1: Working parts of single case and two-case vacuum pumps of water-seal type. Aug. 8: Ratings and capacities of pumps; vacuum pumps are listed in terms of equivalent direct radiation and selected on basis of water and air capacity. Aug. 15: Installation and operation of vacuum pumps. Aug. 22: Describes some actual vacuum heating installations; how to apply pumps to problems of actual heating systems.

HYDRAULIC TURBINES

Blades. The Graphical Determination of the Meridian Paths of Turbine Blades (Sur la détermination graphique des traces méridiennes des aubes des turbines), Eydoux. Académie des Sciences—Comptes Rendus, vol. 181, no. 2, July 15, 1925, pp. 69–70. If turbine be set in the flow for development of mechanical energy, calculation shows that tangential component of vortex does not enter into blade reactions; based upon Lorenz's differential equation for this motion, author describes graphical construction for given curves which show energy exchanges, these curves being in meridian plane owing to above condition.

High-Head. Development of High-Head Hydraulic Turbines, Wm. M. White. Power Plant Eng., vol. 29, no. 24, Dec. 15, 1925, pp. 1262–1268, 8 figs. Changes are largely in bearings, details of construction and methods of speed control.

Reaction. World's Highest Head Reaction Turbine Plant, B. West. Tech. Eng. News, vol. 6, no. 4, Nov. 1925, pp. 146–147, 3 figs. Describes 860-foot head Oak Grove station of Portland Electric Power Co., including discussion of reasons for the development.

HYDROELECTRIC DEVELOPMENTS

Canada. Hydro-Electric Development in Canada, J. C. Smith. Can. Engr., vol. 49, no. 25, Dec. 22, 1925, pp. 651–652. Discusses production of power, amount produced and cost per 1000 hp.; argues against export of power from Canada.

Progress, 1925. Activity in Field of Water Power. Power, vol. 63, no. 1, Jan. 5, 1926, pp. 20–24, 9 figs. New contracts of 1,000,000 hp. reported; propeller-type shows gains; increased efficiency renders development of many low-head sites commercially economical.

HDYROELECTRIC PLANTS

Austria. The Partenstein Hydroelectric Plant in Upper Austria (Das Wasserkraftwerk Partenstein in Oberösterreich), G. v. Troeltsch. Zeit. des Vereines deutscher Ingenieure, vol. 69, no. 48, Nov. 28, 1925, pp. 1485–1492, 17 figs. Describes encatchment area, dams, pressure conduits, a new type of reservoir and pressure pipe line; spiral turbines with vertical shafts are embedded in deep pits; utilized head is 179 m.; turbines have output of 15,400 hp. each.; lubrication of bearings; speed and pressure regulators.

Great Britain. Electricity Supply Developments at Preston. English Elec. Jl., vol. 3, no. 3, Oct. 1925, pp. 115–124, 11 figs. Design and equipment of Ribble power station; 12,500-kw. turbo-alternator sets with condensing plants; one 600-kw. geared d.c. turbo-generator house set, two 600-kw. motor generators and over 32 motors of various sizes for driving auxiliaries; turbine house, boiler house, condensers and extraction pumps, transformers, switchgear, etc.

Niagara. Water-Power Possibilities of the St. Lawrence and Niagara Rivers, H. B. Dwight. Tech. Eng. News, vol. 6, no. 4, Nov. 1925, pp. 144–145, 2 figs. Discusses technical, economical, and political aspects involved in development of 6,000,000-hp. project.

Ontario. Norman Dam Power Development, S. T. McCavour. Contract Rec., vol. 39, no. 49, Dec. 9, 1925, pp. 1158–1160, 6 figs. New dam and power house on western outlet of the Lake of the Woods; five units to be installed at present; details of construction methods.

I

ICE MANUFACTURE

Electric. Electricity in the Manufacture of Ice, D. W. McLenegan. Gen. Elec. Rev., vol. 28, no. 12, Dec. 1925, pp. 846–857, 16 figs. General advantages of electric drive, process of ice manufacture, plant equipment, air compressor; air-storage tanks, ammonia-compressor motor, transformers, ammonia condensers, ice scoring machines.

ICE PLANTS

Design. Many Factors Influence Ice Plant Design, H. J. Macintire. Power Plant Eng., vol. 30, no. 2, Jan. 15, 1926, pp. 151–154, 1 fig. Discusses fundamental principles, showing their application by solution of typical problem in ice-plant design.

Electrically Driven. Performance Test of Electrically Driven Raw Water Ice Plant. Ice & Refrigeration, vol. 69, no. 6, Dec. 1925, pp. 365–368, 4 figs. Report of performance of plant of Fulton Ice Co., New York City, in which author describes operating conditions which made it possible to obtain high efficiency shown; much credit due loyalty and team work of employees.

Hazards. Ice Plant Hazards. South. Engr., vol. 43, no. 10, Dec. 1925, pp. 51–52. Causes of accidents and how to avoid them. Presented at 14th Annual Safety Congress, Cleveland.

INDICATORS

Practical Operation. Practical Operation of the Indicator, W. H. Wakeman. South. Engr., vol. 43, nos. 8, 9 and 10, Oct., Nov. and Dec. 1925, pp. 54–57, 49–53 and 53–56, 90 figs. Diagrams showing what indicator discloses as to what is taking place in engine cylinder; peculiar indicator diagrams and what was done to remedy matters.

INDUSTRIAL MANAGEMENT

Budgeting. My Experience with Many Industries, H. I. Shepherd. System, vol. 48, no. 6, Dec. 1925, pp. 699–701 and 742, 1 fig. Discusses experience in various industries, the budget as a tool of management; set-up and operation of budget.

Industrial Control. Production Control—A Simple System of Recording, W. J. Hiscox. Machy. (Lond.), vol. 27, no. 689, Dec. 10, 1925, pp. 335–336, 4 figs. Describes series of charts which will render efficient service to management of any factory where production is handled on large number of work orders, corresponding to actual sales requirements.

Investigation Department. An Investigation Department in a Typewriter Plant, B. J. Dowd. Am. Mach., vol. 63, no. 26, Dec. 24, 1925, p. 1008. System employed at Hartford plant of Roy. Typewriter Co.; investigation department is made up of force of experts chosen from regular factory force; records of machine operation; standardized forms.

Small Plants. Maintenance Problems in the Small Plant, M. C. Cockshott. Indus. Engr., vol. 83, no. 12, Dec. 1925, pp. 567–572, 6 figs. Discusses difficulties of small plants, employing 100 to 150 men, regarding skilled labor; specialization repairs; how to get best service from belt drives; mill bearings and their lubrication; use of pressure steam in mill lubrication; handling of tools and supplies.

INDUSTRIAL ORGANIZATION

Plant Organization. The Organization of an Industrial Plant, J. Seton Gray. Machy. (N. Y.), vol. 32, no. 5, Jan. 1926, pp. 398–400. Supervision of production; time- and cost-keeping departments; storekeeping department; time study and planning department; employment, inspection and miscellaneous-shop departments; importance of teamwork.

INDUSTRIAL PLANTS

Design Layout. Developing an Industrial Plant around a Process, E. M. Chance. Indus. Mgmt. (N. Y.), vol. 71, no. 1, Jan. 1926, pp. 7–11, 6 figs. Describes new Fort Wayne works of Int. Harvester Co.; points out fundamental factors that require consideration when developing design layout for industrial plant.

Sanitary Survey. How to Make a Sanitary Survey of Your Plant, C. L. Ferguson. Indus. & Eng. Chem., vol. 17, no. 12, Dec. 1925, pp. 1275–1277. Notes on cleanliness, drinking water, ventilation, lighting, exhaust systems, toilets, wash rooms, dressing and rest rooms, etc.

INDUSTRIAL TRUCKS

Electric. Electric Battery Trucks in Industrial Service (Elektrokarren in Industriebetrieben), A. Quick. Elektrischer Betrieb, vol. 23, no. 16, Aug. 24, 1925, pp. 211–213, 5 figs. Applications and advantages of these trucks in industrial service are reviewed, and leading features of several German makes of trucks described; automatic charging equipment eliminates need for continual skilled supervision, and is specially convenient where batteries have to be charged during night.

German. German Electric Trucks (Der deutsche Elektrokarren), H. Hellmich. Zeit. des Vereines deutscher Ingenieure, vol. 69, no. 50, Dec. 12, 1925, pp. 1569–1572, 8 figs. Requirements of electric industrial trucks; electrical equipment and design of truck; economical features.

INSULATION, HEAT

Gas Manufacture, Use in. Insulation, L. E. Cover. Am. Gas Jl., vol. 123, no. 27, Dec. 5, 1925, pp. 611–612 and 620, 2 figs. Its importance in manufacture and domestic and industrial use of gas.

Spun Glass. Spun Glass as Insulating Material (Glasgespinnst als Isoliermittel), Hamester. Wärme- u. Kälte-Technik, vol. 27, no. 20, Oct. 15, 1925, pp. 215–217, 4 figs. Discusses use of glass threads $^1/_{1000}$ mm. in diameter drawn from blocks; advantages for insulating purposes; small weight, fireproof, great resistance, no bad effect on metals, best heat insulator; disadvantages; high cost, hygroscopicity, etc.; comparative cost.

INTERCHANGEABLE MANUFACTURE

Work-Holding Fixtures for. Work Holding Fixtures for the Manufacture of Interchangeable Parts, C. A. Handschin. West. Machy. World, vol. 16, no. 10, Oct. 1925, pp. 399–400 and 415, 3 figs. Examples of special fixtures; points in designing drilling and reaming fixtures.

INTERNAL-COMBUSTION ENGINES

Carbon Deposition. Tests of Carbon Deposition in Internal Combustion Engines, D. R. Brooks. Soc. Automotive Engrs.—Jl., vol. 18, no. 1, Jan. 1926, pp. 48–52, 5 figs. Methods adopted and results obtained in investigation of formation of carbon in internal-combustion engine and its influence on performance of engine, as carried out by series of tests; it was found that special methods of controlling character and quantity of lubricating oil that reached combustion chamber were necessary to obtain concordant results on successive tests.

Double-Expansion. A Double Expansion Internal Combustion Engine. Gas & Oil Power, vol. 21, no. 242, Nov. 5, 1925, pp. 25–27, 5 figs. Design, operation and tests of the Brown engine in which firing takes place at end of compression stroke, expansion of gas acting upon piston until it reaches its complete full stroke, when the exhaust valve opens, and products of combustion are forced out through exhaust pipe by piston sweeping on its fourth stroke; this cycle giving a ratio of double the length of expansion to compression.

Lubrication. Mineral Oil for Lubricating Modern Explosion Engines (Das Mineralöl als Schmiermittel für den modernen Explosionsmotor), E. Pynälä. Petroleum, vol. 21, no. 32, Nov. 10, 1925, pp. 2010–2013. Discusses castor oil used for automobile engines; distillation of Russian mineral oils at Baku to a concentrate having same physical constants as castor oil by Nobel Bros.; use of asphalt test for proving purity of motor oil.

Progress, 1925. Progress of the Internal-Combustion Engine. Power, vol. 63, no. 1, Jan. 5, 1926, pp. 18–19, 5 figs. High-Speed oil engines; Diesel locomotive; large units; transformation of semi-Diesel; high and low-speed gas engines.

[See also AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; GAS ENGINES; GASOLINE ENGINES; OIL ENGINES; SEMI-DIESEL ENGINES.]

IRON CASTINGS

Clutch Couplings. Clutch-Coupling Castings. Metal Industry (Lond.), vol. 27, no. 23, Dec. 4, 1925, pp. 537–539, 9 figs. Describes attempts to produce sound castings of this type, and successful methods finally employed.

Refrigerator Castings. Mechanical Refrigerator Castings, F. A. Schneider. Iron Age, vol. 117, no. 3, Jan. 21, 1926, pp. 205 and 246, 3 figs. Parts must withstand high-pressure test; in quantity production, proper mixture and large risers are essential.

L

LABOR

Employment Policy. A Systematic Scheme for an Employment Policy, Berger. Int. Labour Rev., vol. 12, no. 5, Nov. 1925, pp. 634–649. Outlines scheme for comprehensive employment policy which considers ordinary problems of filling normal vacancies in industrial employment from the available reserve of man power, and extraordinary problems of large-scale unemployment in periods of depression.

LATHES

Multi-Cutting. Multi-Cutting Lathes. Brit. Machine Tool Eng., vol. 3, no. 36, Nov.-Dec. 1925, pp. 329–335, 9 figs. Discusses possibilities of practice installing a standard machine tool modified to suit special work, instead of entirely special machine of new design.

Niles Time-Saving. The Niles Time-Saving Lathe. Engineering, vol. 120, no. 3129, Dec. 18, 1925, pp. 764–765, 5 figs. partly on p. 772. Details of machine made by Niles-Bement-Pond Co. for heavy-duty work.

LEAD ALLOYS

Lead-Antimony. The System Lead-Antimony, R. S. Dean, W. E. Hudson and M. F. Fogler. Indus. & Eng. Chem., vol. 17, no. 12, Dec. 1925, pp. 1246–1247, 2 figs. Solid solubility of antimony in lead at eutectic temperature; solubility of antimony in lead below eutectic temperature; age hardening of lead-antimony alloys.

LIQUIDS

Viscosity. A Kinetic Theory of the Viscosity of Liquids, M. Sato. Tohoku Imperial Univ.—Sci. Reports, vol. 14, no. 4, Oct. 1295, pp. 403–444, 10 figs. Starts from fact that with liquids viscosity decreases greatly with rise of temperature, and develops theory on assumption that important part of liquid viscosity has its origin in mutual action between molecules; field of force due to molecule impact; mean potential energy between two molecules at a given distance; coefficient of viscosity, etc.; develops equation for calculation. (In Japanese.)

LOCOMOTIVES

British Development. The British Steam Railway Locomotive from 1825 to 1924, E. L. Ahrons. Engineer, vols. 139 and 140, nos. 3601–3650, Jan. 6-Dec. 11, 1925, pp. 2–4, 34–37, 66–68, 94–96, 124–126, 151–152, 178–181, 206–208, 232–233, 258–260, 288–290, 316–318, 344–346, 370–372, 398–400, 424–426, 452–454, 478–481, 506–507, 534–536, 562–564, 616–617, 642–644, 670–672, 698–701, 2–4, 28–29, 54–56, 80–82, 104–107, 132–133, 156–157, 180–181, 206–207, 232–233, 258–260, 284–286, 312–314, 338–339, 366–368, 394–395, 422, 452–453, 480–481, 508–510, 538–540, 570–571, 598–600 and 628–629, 314 figs. Traces gradual development during century. Jan. 9: Period 1828–31. Jan. 16 and 23: 1830–1837. Jan. 30 and Feb. 6: 1837–1841. Feb. 13, 20, 27, Mar. 6 and 13: 1841–1849. Mar. 20, 27, Apr. 3 and 10: 1849–1855. Apr. 17 and 24: 1855–1859. May 1: Locomotive performances, speeds and coke consumption, 1845–1859. May 8: Locomotives built by British firms for abroad (including those for Colonial and Indian railways). May 15, 22 and 29: 1860–1865. June 5 and 12: 1866–1869. June 19, 26, July 3 and 10: 1870–1875. July 17 and 24: 1876–1881. July 31: Train resistances and locomotive performances, 1855–1879. Aug. 7: Engines for Ireland and overseas, 1870–1879. Aug. 14, 21, 28, Sept 4, 11, 18 and 25: Compound locomotives, 1882–1889. Oct. 2, 9, 16, 23 and 30: 1890–1900; articulated, steep gradient and miscellaneous locomotives. Nov. 6, 13, 20 and 27: 1901 to 1914. Dec. 4 and 11: 1914–1924.

Coal Trials. Locomotive Coal Trials on the Southern Railway, H. Holcroft. Engineer, vol. 140, no. 3651, Dec. 18, 1925, pp. 658–662, 4 figs. Result of series of trials in order to compare results of using typical South Wales and Yorkshire coals, to ascertain if any appreciable difference in coal consumption is made by passing Welsh coal through mechanical coaling plant, and, incidentally, to observe performance of new 4-6-0 type engines of "King Arthur" class.

Diesel-Electric. Diesel Locomotive Development and Problems, L. Kniel. Diesel & Oil Engine Jl., vol. 1, no. 1, Nov. 1925, pp. 28–39, 18 figs. Details of design and construction; fuel consumption; transmission devices, electric drive, mechanical-gear drive, hydraulic drive and other transmission devices.

Electric. See ELECTRIC LOCOMOTIVES.

Four-Coupled. Four-Coupled Passenger Locomotive in Europe (Die vierfach gekuppelte Personenzuglokomotive in Europa), R. Dannecker. Organ für die Fortschritte des Eisenbahnwesens, vol. 80, no. 20, Oct. 30, 1925, pp. 411–419, 4 figs. Discusses development of 1 D, 1 D 1, 2 D and other types and gives a list with tabular data of 36 types used in various European countries.

Light. Baguley-Clarkson Locomotive for the Egyptian Delta Light Railway. Engineering, vol. 120, no. 3130, Dec. 25, 1925, pp. 800–801, 11 figs. partly on p. 804. Locomotive built to order of Egyptian Delta Light Ry. Co., by Baguley, Ltd., Burton-on-Trent, Eng., for hauling one or two passenger coaches only on suburban service at 20 m.p.h. with frequent stops.

Lima. A Summary of Tests Obtained with Lima Locomotives. Ry. & Locomotive Eng., vol. 38, no. 12, Dec. 1925, pp. 341–343, 1 fig. Results of 5 years of experimental work.

Lubrication. Lubrication of the Parts Exposed to Steam of a Superheater Locomotive (Die Schmierung der unter Dampf gehenden Teile der Heissdampflokomotive), R. P. Wagner. Zeit. des Vereines deutscher Ingenieure, vol. 69, no. 51, Dec. 19, 1925, pp. 1589–1598, 25 figs. It is shown that introduction of superheated steam in locomotive operation renders it necessary to use new kinds of oil and high-pressure piston lubricating pumps; development of pumps used by German State Ry. and other lubricating equipment.

Oil-Electric. Oil Electric Locomotive Makes Record Run. Ry. Age, vol. 79, no. 26, Dec. 26, 1925, pp. 1190–1192, 5 figs. Travels 537 mi. in 28 hr. 45 min. with load of 377 tons on 473 gal. of fuel oil; built jointly by Gen. Elec. Co., Ingersoll-Rand Co. and Am. Locomotive Co. for Long Island R.R.

Oil-Electric vs. Steam. Oil-Electric versus Steam Locomotives, W. W. Baxter. Ry. Rev., vol. 77, no. 24, Dec. 12, 1925, pp. 871–874, 4 figs. Operation in actual service indicates relative performance and cost of two sources of motive power.

Superheater. 2D-Superheat Four-Cylinder Compound Express Locomotive for North Railway of Spain (2Dl-Heissdampf-Vierzylinder-Verbund-Schnellzuglokomotive der Spanischen Nordbahn), Adolf Wolff. Hanomag Nachrichten, vol. 12, nos. 143/144, Sept.-Oct. 1925, pp. 145–165, 33 figs. Details of design and construction of new type.

Tenders. Rock Island Remodels Vanderbilt Type Tenders. Ry. Mech. Engr., vol. 99, no. 12, Dec. 1925, pp. 747–749, 3 figs. Tank of new design applied to standard underframe; capacity increased to 10,000 gal.; maintenance cost reduced.

Testing Plant. The Locomotive Testing Plant, A. I. Lipetz. Mech. Eng., vol. 48, no. 1, Jan. 1926, pp. 36–38. Discussion of paper by L. H. Fry, published in Mech. Eng., Nov. 1925. Early stationary tests and testing plants in Europe; efficiency of draft-producing action of exhaust; reliable data obtainable from road tests; influence of Purdue plant on European locomotive design.

Three-Cylinder. The Three-Cylinder High-Pressure Locomotive, H. N. Gresley. Instn. Mech. Engrs.—Proc., no. 4, May 1925, pp. 927–967 and (discussion), 968–986, 24 figs. Early history and recent developments; tests with 3-cylinder engines; uniformity of starting effort; increased mileage between repairs; steady running at high speeds and decreased hammer blow; decreased fluctuation in smoke-box vacuum; advantages of 3-cylinder locomotive. Appendices give tables on comparative tests with 2- and 3-cylinder 4-4-2 engines and with 2- and 3-cylinder 2-8-0 engines, selected examples of 3-cylinder high-pressure locomotives, and particulars.

2-10-4 Freight. New Type Locomotive for Texas & Pacific, W. W. Baxter. Ry. Rev., vol. 77, no. 25, Dec. 19, 1925, pp. 905–912, 10 figs. Engines having 2-10-4 wheel arrangement and 4-wheel booster equipped with articulated trailing trucks placed in service.

LUBRICANTS

Manufacture. Using Oils and Greases for Industrial Lubrication, F. E. Gooding. Indus. Engr., vol. 83, no. 12, Dec. 1925, pp. 558–566, 4 figs. Discusses properties, sources of oil lubricants, blending and compounding; manufacture of lubricating greases; graphite and its action on scored bearings; effect of speed on charge of lubricant, etc.

Properties and Uses. Lubricants and Their Use (Ueber Schmierstoffe und ihre Verwendung), Buchholz. Kraftmaschine, vol. 22, no. 13–14, July 1925, pp. 130–132. Discusses process of lubrication; cohesion, viscosity, flashpoint, solidification point; use of mineral oils, tallow graphite; economic use of lubricants.

LUBRICATING OILS

Carbon-Residue Test. The Carbon Residue Test for Lubricating Oils, W. M. Seaber. Indus. Chem., vol. 1, no. 2, Mar. 1925, pp. 79–80, 1 fig. Carbon residue test, known in United States as Conradson test, has certain drawbacks, chief of which is lack of control over temperature around crucibles; describes some of the results obtained, using an electric furnace whereby temperature can be controlled with limit of 5 deg. fahr.; it would appear that there is a distinct advantage over Conradson apparatus, using this method of heating oil, more concordant results being obtained.

Filtering. Contact Filtering of Lubricating Oil Successful at Ohio Refinery, P. Truesdell. Nat. Petroleum News, vol. 17, no. 47, Nov. 25, 1925, pp. 78–83, 1 fig. New process of the Solar Refining Co.

Refining. Lubricants, Lubrication and Insulating Oils, R. W. L. Clarke. Instn. of Petroleum Technologists—Jl., vol. 11, no. 51, Aug. 1925, pp. 337–342. Reviews literature on subject, including preparation, refining of oils, properties, oils and lubrication; insulating oils for transformers, etc.

M

MACHINE-TOOL INDUSTRY

Germany. The Productive Capacity of German Machinery Works. Engineer, vol. 140, no. 3650, Dec. 11, 1925, pp. 645–646. Review of report by Lange to Verein Deutscher Maschinenbau Anstalten, dealing with economic crisis and means of meeting it, and showing how productive capacity of country had greatly outstripped requirements of home and foreign markets; points to necessity of restricting means of production.

MACHINE TOOLS

Annual Digest, 1925. Tool Builders Introduce Machines for Higher Production, E. F. Ross. Iron Trade Rev., vol. 78, no. 1, Jan. 7, 1926, pp. 30–32 and 48, 8 figs. Recapitulation of machine tools and other equipment developed for machine-shop use and described in 12 monthly digests in this journal in 1925.

Developments, 1925. New Machine Tools. Machy. (Lond.), vol. 27, no. 690, Dec. 17, 1925, pp. 372–400, 61 figs. Details of lathes, chucking machines, drilling machines, milling machines, grinding and lapping machines, wheel lathes, etc. See also pp. 401–405, giving capacity list and summary of improved features.

Machine Tool Developments in 1925. Machy. (Lond.), vol. 27, no. 690, Dec. 17, 1925, pp. 363–371. Review of principal improvements in design.

Drive. Contribution to Theory of Step Cone Gearing for Main Drive of Machine Tools (Beitrag zur Theorie der Stufenrädergetriebe im Hauptantriebe von Werkzeugmaschinen), Kryspin-Exner. Werkstattstechnik, no. 21, Nov. 1, 1925, pp. 757–767, 29 figs. Discusses simplest possible drives for producing limited number of steps in geometric ratio; two-shaft and three-shaft drives; Norton steps; back gears.

Economics. Machine-Tool Economics (Wirtschaftliche Leistungsnutzung an Arbeitsmaschinen), F. Theimer. Maschinenbau, vol. 4, no. 23, Nov. 19, 1925, pp. 1119–1124, 6 figs. Discusses determination of operating times to keep machines fully employed and develops equations and tables for the purpose; proper division of work leading to better quality and considerable saving.

Fluting Machine. Roller Fluting Machine. Brit. Machine Tool Eng., vol. 3, no. 36, Nov.-Dec. 1925, pp. 347–349, 4 figs. Design and operation of new machine by J. Parkinson & Son for fluting of rollers used in connection with textile machinery, which can also be used for machining of splines of castellated shafts, cutting of teeth on long gear pinions, etc.

New Types. Shop Equipment Review. Am. Mach., vol. 64, no. 3, Jan. 21, 1926, pp. 79–141. Semi-annual résumé of machines, tools and accessories described in Shop Equipment News section of this journal during last six months of 1925.

Portable. Portable Machine Tools. Machy. (Lond.), vols. 26 and 27, nos. 677, 678, 679, 680, 681 and 682, Sept. 10, 24, Oct. 1, 8, 15 and 22, 1925, pp. 769–782, 815–817, 1–4, 33–37, 83–89 and 97–100, 80 figs. Discusses more recent developments and describes their application; class of tools dealt with range from large duplex spindle milling machines, shaping, slotting, facing, boring and duplex spindle drilling and tapping machines, down to small electric and pneumatic hand tools such as drills and grinders; examples are included of practice in shipbuilding yard, locomotive-building and repair shop, heavy electrical machine shop, maintenance department of coal mine, power station, rubber factory, and motor-repair station.

Replacement Policy. Getting the Most Out of Your Machine Tool Dollar, G. S. McKee. Am. Mach., vol. 63, no. 26, Dec. 24, 1925, pp. 995–997. Policy of replacement of obsolescent machine tools in plants of Timken Roller Bearing Co.

Getting the Most Out of Your Machine Tool Dollar, Wm. Hartman. Am. Mach., vol. 64, no. 1, Jan. 7, 1926, pp. 1–4. Practice followed by Nat. Cash Register Co.; See also article, by P. S. Brown, under same title, in no. 5, Feb. 4, 1926, pp. 183–186, describing practice of Corona Typewriter Co.

Selection. Standard Machine Tools. Times Trade & Eng. Supp., vol. 17, no. 379, Oct. 10, 1925, p. 99. Discusses lathe and its derivatives, turret lathes and automatic lathes, drilling machines and gear-cutting machines; adoption of new machine tools and subsequent increase in output, especially in automobile industry.

Tool-Changing Devices. The Rapid Changing of Tools, Wm. Mason. West. Machy. World, vol. 16, no. 11, Nov. 1925, pp. 449–450, 4 figs. Use of auxiliary tool changing fitment; properly made tool-changing devices; quick-change chucks.

MACHINERY

Safety Devices. Engineering Revision and Mechanical Safeguarding, E. W. Beck. Nat. Safety News, vol. 12, no. 6, Dec. 1925, pp. 9–12, 6 figs. General principles for mechanical safeguards; they should not interfere with operations, should be strong enough to withstand more than wear and tear, simple and easily accessible; daily inspection necessary; familiarity of workmen in operating them, etc.; gives examples.

Shipping, Engineering & Machinery Exhibition, Olympia. The Shipping, Engineering and Machinery Exhibition. Engineer, vol. 140, nos. 3647 (including supp.), 3648, 3649, 3650 and 3651, Nov. 20, 27, Dec. 4, 11 and 18, 1925, pp. 555–560, 22 figs. and 20 pp. in supp. with 75 figs.; 571–575, 18 figs.; 602–606, 16 figs.; 629–633, 17 figs.; and 662–667, 23 figs. Account of principal objects on view, classified according to makers, but not alphabetically. See also Engineering, vol. 120, nos. 3126, 3127, and 3128, Nov. 27, Dec. 4 and 11, 1925, pp. 668–675 and 678, 703–707 and 710, and 728–735, 76 figs., partly on supp. plates.

Size Series. Basis of Determining Arrangement and Choice of Size Series (Ueber die Crundlage der Typung und die Wahl der Abstufungsreihen), Hellborn. Technik und Wirtschaft, vol. 18, no. 11, Nov. 1925, pp. 309–313, 6 figs. Discusses mathematical basis of deciding on size series of machines and manufactured products, and concludes that the higher arithmetical series are most suitable; develops examples of series.

MACHINING METHODS

Automobile Cylinder Blocks. Willys-Knight Production Methods, F. H. Colvin. Am. Mach., vol. 64, no. 4, Jan. 28, 1926, pp. 147–150, 10 figs. Methods that have been developed in cylinder-block manufacture to meet demand for large output of sleeve-valve engines.

MAGNESIUM

Properties and Manufacture. Magnesium: A Metal with a Future, L. P. Sidney. Chem. Age (Lond.), vol. 13, no. 334, Nov. 7, 1925, pp. 33–34. Relation to aluminum, properties and occurrence, process of manufacture, properties in fibrous condition, and use for castings.

MANGANESE STEEL

Heat Treatment. Describes Results of Tests in

Manganese Steel, Rob. Hadfield. Iron Trade Rev., vol. 77, no. 26, Dec. 24, 1925, pp. 1597–1598, 4 figs. Effect of special heat treatment; test results show that by appropriate heat treatment, manganese steel can be made hard and magnetic at same time. From paper read before French Congress of Chemical Industry, Paris.

METAL DRAWING

Heavy Sheet Steel. Examples of Heavy Sheet Steel Drawing, E. Sheldon. Am. Mach., vol. 63, no. 27, Dec. 31, 1925, pp. 1035–1038, 6 figs. Advantage taken of tendency of metal to thicken up; shells produced having wide variation in thickness of wall; drawing steel that is more than ¼ in. thick.

METALLOGRAPHY

Engineers. Metallography for Engineers, W. Rosenhain. Metallurgist (Supp. to Engineer), Nov. 27, 1925, pp. 168–171, 7 figs. Failures and defects.

Photomicrographs. Photo-Micrographs. Metallurgist (Supp. to Engineer), Dec. 25, 1925, pp. 184–187, 4 figs. Discusses fundamental question as to whether all etching reagents produce same pattern on a given specimen; describes examples which serve to show that all structures which can be developed on given surface by different reagents are closely correlated, and can be rightly regarded as different aspects of same structure; choice of magnification, interpretation of photomicrographs.

METALS

Cold Working, Effect of. Effect of Cold Working on Endurance and Other Properties of Metals, D. J. McAdam, Jr. Am. Soc. Steel Treating—Trans., vol. 8, no. 6, Dec. 1925, pp. 782–836, 41 figs. Part I: Presents graphs illustrating effect of cold working on tensile strength, yield point, shearing strength, yield ratio, shear ratio, and Meyer hardness indices; discusses possible relationship between effect of cold working on these properties and effect on endurance limit; effect of cold working on alternating-torsion endurance limit of nickel. Part II: Presents graphs illustrating effect of cold working on ductility and on strength values, calculation of which depends on ductility values; results are plotted with percentage increase in tensile strength due to cold working.

Deformation. Basic Phenomena of Plastic Deformation (Die grundlegenden Vorgänge der bildsamen Verformung), H. Meyer and F. Nehl. Stahl u. Eisen, vol. 45, no. 48, Nov. 26, 1925, pp. 1961–1972, 31 figs. Discusses theoretical principles of compression tests as aid in analysis of phenomena in connection with forging, pressing and rolling; review of most important investigations of compression and impact tests.

Engineering and Science in Metal Industry. Engineering and Science in the Metal Industry, Z. Jeffries. Mech. Eng., vol. 48, no. 1, Jan. 1926, pp. 8–16, 15 figs. Growth of metal industries since 1885; selecting best metal or alloy for given purpose; factors governing properties of alloy; causes of hardness in steel; effect of science on metal industry.

Fatigue of. An Investigation of the Fatigue of Metals. Univ. Ill. Bul., vol. 23, no. 12, Nov. 23, 1925, 92 pp., 29 figs. Methods and apparatus used in investigation; concludes that at elevated temperatures a marked difference was found between ultimate tensile strength as determined by ordinary static tension tests and as determined by prolonged and retarded tension tests; of metals tested, those having high nickel content showed least falling off of ultimate tensile strength and proportional elastic limit as temperatures were increased, etc.

X-Ray Examination. X-Ray Examination of Inner Structure of Strained Metals, Iron Plastically Strained in Extension, Compression and Torsion, A. Ono. Kyushu Imperial Univ. College of Eng.—Memoirs, vol. 3, no. 6, 1925, pp. 267–286, 7 figs. Discusses crystal rearrangement as observed in X-ray examination of metals, plastically strained in extension, compression and torsion; also mechanism of crystal rearrangement and cost of strain hardening.

MILLING CUTTERS

Standard Sizes. Sizes of Standard Milling Cutters (Simplified Practice). Am. Mach., vol. 64, nos. 1 and 2, Jan. 7 and 14, 1926, pp. 31 and 71. Reference-book sheet for involute gear cutters, sprocket-wheel cutters for roller chains, angular cutters, double-angle cutters, and cutters for fluting reamers.

MOMENTS

Graphical Treatment. Graphical Treatment of Moments, W. W. Padfield. Machy. (Lond.), vol. 27, no. 688, Dec. 3, 1925, pp. 293–295, 9 figs. Useful method for preliminary designing; shows that by means of moments many constantly recurring engineering problems may be solved simply and neatly.

MOLDING MACHINES

Non-Repetition Foundries. Machines in Non-Repetition Foundries, Geo. Edginton. Foundry Trade Jl., vol. 32, no. 485, Dec. 3, 1925, pp. 463–466, 22 figs.; and (discussion), no. 486, Dec. 10, 1925, pp. 499–500. Describes types of machines used at Broadoaks foundry, including jolting machines, sand slinger, shake-out table, etc.

Types. Moulding Machines. Foundry Trade Jl., vol. 32, nos. 480 and 482, Oct. 29 and Nov. 12, 1925, pp. 370–372 and 403–408, 35 figs. Oct. 29: Early work on mechanical molding; hydraulic machines. Nov. 12: Centrifugal casting; stripping plates; jolt machines; hydraulic molding machines; built-up pattern plates.

MOLDING METHODS

Strickle Molding. A New Method of Strickle Moulding. Foundry Trade Jl., vol. 32, no. 485, Dec. 3, 1925, p. 474. New method of molding invented by Sappin Freres, which obviates pulls occurring during stripping process when walls of casting are vertical or have not sufficient taper. Brief abstract from paper read before Franco-Belgian Foundry Congress.

MOLDS

Ingot. Ingot Moulds. Foundry Trade Jl., vol. 32, no. 485, Dec. 3, 1925, p. 470, 2 figs. One method of making ingot molds is by molding vertically on jolting machine; points out weaknesses of this and other methods and recommends a much safer method of molding entirely by hand.

MOTOR-BUS TRANSPORTATION

Street Railways, Coördination with. Can Motorcoaches Relieve Traffic Congestion?, P. B. Harris. Soc. Automotive Engrs.—Jl., vol. 18, no. 1, Jan. 1926, pp. 33–34. After comparing some of major advantages of motor coaches and electric street cars in transportation service, author asserts that electric-railway companies believe that motor-coach lines have future as feeders, but that to be successful they must be operated by same companies that operate rail lines.

MOTOR BUSES

Development. The Bus as a Mass Transportation Carrier, W. W. Harris. Engrs. & Eng., vol. 42, no. 12, Dec. 1925, pp. 321–323. Discusses possibility of bus as a carrier, in competition with street cars, railroads, taxis, etc.; increasing bus traffic in London; comparison of New York traffic; congestion of streets, and efficiency of the motor bus.

The Motorbus as an Adjunct to the Street Railway, R. H. Horton. Engrs. & Eng., vol. 42, no. 12, Dec. 1925, pp. 324–325. Discusses anomalous position of motor buses operating more cheaply in one locality and electric cars in another; major features to be considered being investment, depreciation, platform labor and maintenance; conditions in Philadelphia.

Gasoline-Electric. Operating Experience with Gasoline Electric Motorcoaches, R. H. Horton. Soc. Automotive Engrs.—Jl., vol. 17, no. 6, Dec. 1925, pp. 592–596. Results obtained in 5-months operation of fleet of 130 gasoline-electric single-deck pneumatic-tire and double-deck dual-solid-tire motor coaches by Philadelphia Rural Transit Co.; outstanding advantages realized in operation of this type of motor coach are enumerated, as well as troubles that have been overcome.

Lubrication. Lubrication of the Motor Bus. Lubrication, vol. 11, no. 11, Nov. 1925, pp. 121–132. Conditions affecting cold-weather lubrication, water in gasoline, and in lubricating oil, crankcase dilution, carbon formation, selection of motor oils; electric equipment; transmission and differential or rear-end drive.

Standardization and Design. The Motorcoach and the Railroad, H. F. Fritch. Soc. Automotive Engrs.—Jl., vol. 17, no. 6, Dec. 1925, pp. 583–591, 11 figs. Discusses possibilities of standardizing motor-coach design and emphasizes point that greatest demand for variation from standard practice is in construction of body rather than in chassis; deals also with use of proper springs, improvement of brakes as regards effectiveness, necessity for providing sufficient aisle and seating space, selection of outside body sheathing and painting.

MOTOR TRUCKS

Air Brakes for. Use of Compressed Air Brake for Motor-Truck Trains (Die Anwendung der Druckluftbremse bei Automobillastzügen), Spettmann. Praktischer Maschinen-Konstrukteur, vol. 58, no. 40, Oct. 6, 1925, pp. 628–631, 5 figs. Details of design and operation of four-wheel brakes for trucks and trailers on principle of Knorr brake for railways.

British Show. The Commercial Vehicle Show. Engineer, vol. 140, nos. 3644, 3645, and 3646, Oct. 30, Nov. 6 and 13, 1925, pp. 457–460, 485–488, and 512–515, 35 figs. partly on plate. Tendencies in design manifested by exhibits at Seventh International Commercial Motor Transport Exhibition at Olympia. Details of various exhibits. See also Engineering, vol. 120, no. 3123, Nov. 6, 1925, pp. 570–574 and 578, 12 figs.

Military. The Requirements of the Military Motor Vehicle, R. K. Hubbard. Automobile Engr., vol. 15, no. 210, Dec. 1925, pp. 455–458, 6 figs. Discussion is confined to vehicles that have their counterpart in hands of civil user; deals with military requirements under heads of performance, and general design and constructional detail. (Abstract.)

Producer-Gas. The Franco-Belgian Trials of Producer Gas Lorries. Gas & Oil Power, vol. 21, no. 242, Nov. 5, 1925, p. 29. Details of recent trial over a 1245-mi. course of 15 trucks, including Renault, Berliets, Schulz, Panhard and other types.

Wind Resistance. Wind Resistance of Motor Vehicles, L. E. Conrad. Pub. Roads, vol. 6, no. 9, Nov. 1925, pp. 203–206, 6 figs. Progress report of tests conducted by Kansas State Agricultural College in cooperation with Bureau of Public Roads. Resistance of full-sized cars measured in wind tunnel; develops equation for calculation.

N

NOZZLES

Steam, Design of. Fourth Report of the Steam-Nozzle Research Committee. Instn. Mech. Engrs.—Proc., no. 4, May 1925, pp. 747–843, 31 figs. Deals with 12-deg. convergent impulse nozzles with thin and with thick blades; built-up type of impulse nozzle; test results of straight elementary nozzles; efflux angles of steam; superheat effect. Includes discussion.

O

OFFICE MANAGEMENT

Development. The Present State of the Art of Office Management, W. H. Leffingwell. Soc. Indus. Engrs.—Bul., vol. 7, no. 12, Dec. 1925, p. 10. Discusses management as the art of handling men, materials and machinery for purpose of producing certain desired results, measurement of work done and method of rating the various operations.

OIL ENGINES

Combustion. A Study of Combustion Events Taking Place in an Oil Engine, O. Mader. Power, vol. 63, no. 4, Jan. 26, 1926, pp. 132–133, 3 figs. Comparison of 4-stroke-cycle and 2-stroke-cycle engines; what aim of new designers should be. (Abstract.) Translated from Zeit. des Vereines deutscher Ingenieure, Oct. 31, 1925.

Crankless. Tilting Thrust Blocks on Crankless Engines. Oil Engine Power, vol. 3, no. 11, Nov. 1925, pp. 649–650, 4 figs. Discusses application of swash plates in oil-pressure transmissions for converting reciprocating into rotary motion and vice versa, and gives example of its application to two-cycle airless-injection oil engine with four 7½ x 9-in. cylinders rated to deliver 100 hp. at 500 r.p.m.; also application to gas engines.

Failures. Reasons for Oil Engine Failures, C. H. S. Tupholme. Power Plant Eng., vol. 30, no. 2, Jan. 15, 1926, pp. 137–139. Misalignment, improper lubrication, and failure of cooling water are most important points.

Fuel-Pump Adjustment. Oil-Engine Fuel-pump Adjustments, Rob. Melrose. Power, vol. 62, no. 26, Dec. 29, 1925, pp. 1014–1015, 2 figs. Fuel pumps are classified under two headings, those wherein supply of oil per stroke is controlled by governor regulating time of closure of pump suction valve, and type where amount of oil delivered is controlled by altering stroke of fuel-pump plunger.

Heavy-Oil. Two-Stroke Crude Oil Engine. Engineer, vol. 141, no. 3656, Jan. 22, 1926, p. 108, 4 figs. Vertical crude-oil engine put on market by Crossley Bros., Manchester, in 1924; details of internal mechanism; fuel-consumption data of 14-b. hp. engine.

Solid-Injection. Dutch Oil Engine Design, H. F. Birnie. Power Plant Eng., vol. 30, no. 3, Feb. 1, 1926, pp. 210–211; 5 figs. Hot-bulb-type engine uses low compression and airless injector; developed by Kromhout Co., Amsterdam, Holland, and used for marine work.

Tests with Boiler Oil in a Hesselman Airless-Injection Engine, E. Lundgren. Power, vol. 63, no. 3, Jan. 19, 1926, pp. 97–98, 1 fig. Tests carried out with heavy Mexican boiler oil in Hesselman engine under supervision of Prof. E. Hubendick, of Roy. Univ. of Technology of Stockholm, indicate that properly designed solid-injection engine will handle heaviest of oils.

Two-Stroke. Some Tests on a Two-Stroke Cycle Oil-Engine, E. A. Allcut. Instn. Mech. Engrs.—Proc., no. 4, May 1925, pp. 819–881 and (discussion) 882–909, 21 figures. Tests made to investigate behavior of engine under different loads, to ascertain extent of various heat losses and various efficiencies; as suitable oil calorimeter was not available for student and laboratory work, experiments described in appendices were undertaken with object of designing such a calorimeter.

OIL FUEL

Burners. Oil-Fired Cast-Iron and Steel Boilers Show High Combined Efficiency. Heat & Vent. Mag., vol. 22, no. 12, Dec. 1925, pp. 71–74, 1 fig. Results of three series of tests, one with an A.B.C. burner, one with a Winslow industrial-type burner, and third with a Johnson burner.

Burning, Requirements for. Burning Fuel Oil, F. A. Rothwell. Power Plant Eng., vol. 30, no. 1, Jan. 1, 1926, pp. 23–26, 5 figs. Discusses more important factors governing successful burning of fuel oil.

Methods Used in Burning Oil Fuel under Boilers. Power Plant Eng., vol. 30, no. 1, Jan. 1, 1926, pp. 26–30, 6 figs. Starting up, control of fuel and air, checks on performance, shutting down; storage and handling, special precautions.

Purification. Fuel and Lubricating Oil Purification Reviewed, L. H. Clark. Oil Engine Power, vol 3, no. 12, Dec. 1925, pp. 700–702, 4 figs. Use of centrifugal machines for purifying oils; impurities of lubricating oils and their detrimental action on engines; drawbacks in purification of fuel oils and how to overcome them.

OPEN-HEARTH FURNACES

Acid Steel Melting. Acid Open Hearth Steel Melting Practice, R. Furness. Am. Soc. Steel Treating—Trans., vol. 8, no. 6, Dec. 1925, pp. 728–736 and (discussion) 736–738. Outlines characteristics of acid open-hearth furnace, and gives contributing cause of superiority of acid open-hearth steel over basic; discusses melting charge and methods given for controlling elements in bath, as well as proper time to make additions; gives proper conditions of bath to obtain satisfactory results from oring the heat; discusses acid open-hearth slags.

Basic Steel Melting. The Basic Open Hearth Practice, E. A. Whitworth. Am. Soc. Steel Treating—Trans., vol. 8, no. 6, Dec. 1925, pp. 739–744 and (discussion) 744–747. History of basic open-hearth steel-melting practice; furnace design; practice for high-grade carbon forging steel.

OXYACETYLENE WELDING

Copper. Autogenous Welding of Copper by the Oxyacetylene Process, A. Eyles. Am. Mach., vol. 63, no. 27, Dec. 31, 1925, pp. 1043–1045, 14 figs. Char-

acteristics of copper, especially when in moltent state; fluxes not necessary; precautions to be taken in making sound welds; welded joints and their preparation.

Power Plants. The Welding and Cutting Torch in the Power Plant, L. A. Cowles. Power, vol. 63, no. 4, Jan. 26, 1926, pp. 146–148, 5 figs. Author tells of 30 power-plant jobs—no two exactly alike—on which torch has saved time, money and trouble.

P

PLANERS

Plate-Edge. A Large Plate Edge Planing Machine. Engineer, vol. 140, no. 3652, Dec. 25, 1925, p. 700, 1 fig. A 66-ft. planing machine built by Smith Bros. & Co., Glasgow, for use in connection with Sydney Bridge contract.

Roll Wabbler. Roll Wabbler Planer. Iron Age, vol. 116, no. 27, Dec. 31, 1925, p. 1807, 2 figs. Heavy traveling head machine, placed on market by Morton Mfg. Co., Muskegon Heights, Mich., accommodates rolls up to 56 in. in diam.

POWER

Equipment, European Developments. Power Equipment Developments in Europe, J. H. Blakey. Power Plant Eng. vol. 29, no. 24, Dec. 15, 1925, pp. 1281–1281, 2 figs. French-patented progressive-action friction clutch; rupture tests on steel stirrups carried out by Central Bureau of Normalization of Delft, Holland; mandrel for spreading ends of boiler tubes designed by German firm of Steinmüller; annealing of plates for electrical machines.

Power Show, New York City. Fourth Power Show Surpasses Predecessors. Power Plant Eng., vol. 30, no. 1, Jan. 1, 1926, pp. 94–106, 5 figs. Pulverized-coal and combustion apparatus are centers of interest; steam turbines; centrifugal and reciprocating pumps; electrical equipment; furnace construction; valves and valve control; steam and vacuum traps; feedwater control; piping system and equipment; water heating and steam superheating; etc.

Progress, 1925. Year's Progress in Power Field Shows Many Marked Advances. Power, vol. 63, no. 1, Jan. 5, 1926, pp. 2–4, 3 figs. Results obtained from large new steam plants show remarkable reduction in fuel consumption; condensing steam station has operated on heat rate of 13,715 B.t.u. per kw-hr.; tests on hydroelectric units have shown combined overall efficiencies of 92 per cent for turbine and generator; improvements in furnace designs, etc.

POWER TRANSMISSION

Applications. The Control of Mechanical Power Transmission, Wm. Staniar. Indus. Mgmt. (N. Y.), vol. 71, no. 1, Jan. 1926, pp. 49–54, 14 figs. Discussion of transmission applications; chain transmission; silent chains; roller transmission chains; speed transformers work reduction gear; spur-gear speed transformer; variable speed mechanism.

Tools. Press Tool Design of the American Multigraph Company, W. E. Irish. Am. Mach., vol. 64, no. 2, Jan. 14, 1926, pp. 47–49, 8 figs. Combination of press and forming rolls; forming a cylinder in one operation; examples of finger forming tools to combine vertical and horizontal tool movements.

Some Multiple-Operation Press Tools, W. E. Irish. Am. Mach., vol. 64, no. 5, Feb. 4, 1926, pp. 187–190, 9 figs. A two-draw cup-forming tool; blanking centerholing and forming combined; forming cylinder in a side-acting tool; universal four-way tool.

PULVERIZED COAL

Boiler Firing. Development of Modern Pulverized-Coal Firing (Beiträge Zur Entwicklung der neuzeitlichen Kohlenstaubfeuerung für Dampfkessel). Gwosdz. Brennstoff u. Wärmewirtschaft, vol. 7, no. 20, Oct. 2, 1925, pp. 407–409, 2 figs. Reviews American, British and German patents on development of furnace and ash pit.

Powdered Coal Universal Fuel at American Spiral Pipe Works. Power, vol. 63, no. 4, Jan. 26, 1926, pp. 126–130, 4 figs. Installation of modern boiler utilizing pulverized coal; pulverized-coal feeders were equipped with dual motor drives which take current from plant or from central-station service, and duplicate blowers were provided to supply primary air; rules for safe operation of pulverized-coal plant.

Pulverizers. Pulverized Coal at the Furnace, E. C. Kreutzberg. Foundry, vol. 54, no. 1, Jan. 1, 1926, pp. 7–8, 3 figs. Coal is prepared for use in individual device close to furnace instead of being piped from central station; use of pulverizer has effected large saving in total melting costs as compared with cost of operating hand-fired furnace, in foundry of Kuebler Foundries, Easton, Pa.

Requirements for Burning. Requirements for Burning Pulverized Fuel, H. D. Savage. Power Plant Eng., vol. 30, no. 1, Jan. 1, 1926, pp. 14–15. Economic results from pulverized fuel; coal-burning conditions made possible presage radical changes in plant design.

Systems. Pulverized Coal Systems of 1925, A. Scheffler. Power Plant Eng., vol. 29, no. 24, Dec. 15, 1925, pp. 1251–1254, 4 figs. Growth of method, typical results and new developments.

Unit System. Unit System for Powdered Coal are Successful, W. C. Heckeroth. Power Plant Eng., vol. 29, no. 24, Dec. 15, 1925, pp. 1254–1255, 3 figs. Ability to serve small and large plants, dependability and ability to use any fuel are factors.

PUMPING STATIONS

Automatic. Automatic Pumping Stations. Brown Boveri Rev., vol. 12, no. 12, Dec. 1925, pp. 251–261, 21 figs. Electrically driven centrifugal pumps used in connection with water supply for isolated dwellings, hotels, and large establishments, industrial and agricultural purposes, and whole towns, developed by Brown Boveri.

PUMPS, CENTRIFUGAL

Turbine. Tests of Deep-Well Turbine Pumps, F. L. Bixby. Agricultural Research—Jl., vol. 31, no. 3, Aug. 1, 1925, pp. 227–237, 8 figs. Details of pump; modification of vertical centrifugal pump so designed as to obviate necessity of constructing a pit where depth to water is beyond practical limit for installing centrifugal pumps; it is built up in vertical units or bowls one above the other; results of tests.

PYROMETRY

Methods. Pyrometry, J. L. Haughton. Metallurgist (Supp. to Engineer), Nov. 27 and Dec. 25, 1925, pp. 162–165 and 179–181, 9 figs. Notes on platinum-resistance, thermoelectric, and radiation pyrometry.

R

RAILS

Failure. An Examination into the Causes of the Failure of Steel Rails, E. A. Dancaster. Indus. Chemist, vol. 1, no. 9, Oct. 1925, pp. 441–448, 6 figs. Describes how examination of piece of rail is carried out, in connection with a series of investigations being carried out by author in conjunction with W. H. Shortt into microstructure of rails which have failed in service.

Steel. Recent Developments in Rail Steel. Iron Age, vol. 117, no. 5, Feb. 4, 1926, pp. 336–338. Contains following two articles: A Special Manganese Rail and Its Advantages, describing patent specifications and claims for a new special manganese steel; Transverse Fissures—Discovery, Cause and Remedy, outlining latest aspects of transverse-fissure problem, what has been learned thus far and what remedy is, if any.

RAILWAY ELECTRIFICATION

Great Britain. Traction Motors and Substation Equipment for the Southern Railway. English Elec. Jl., vol. 3, no. 3, Oct. 1925, pp. 105–114, 12 figs. Details of electrification of first part of suburban lines of South-Eastern and Chatham Railway, operating on direct current at 660 volts, led to the trains by the conductor rail, running rail being used as a return; power in bulk from Deptford Station of London Electric Supply Corp. to railways; main distribution at Lewisham in the form of three-phase, 25-cycle supply at 11,000 volt; motor equipment, rotary converters, switchgear, substations.

RAILWAY MANAGEMENT

Statistics, Value of. Statistics and Their Value in All Phases of Railway Economics, W. E. Symons. Ry. & Locomotive Eng., vol. 38, no. 12, Dec. 1925, pp. 354–355, 1 fig. Gives illustrations of great value of comparative statistics in all phases of railway ownership and operation.

RAILWAY MOTOR CARS

Developments. Application of Mechanical Transmission in Traction on Rails (De l'application de la Transmission Mécanique à la traction sur les voies ferrées), G. Alleaume. Arts et Métiers, vol. 78, nos. 56, 57 and 59, May, June and Aug., 1925, pp. 161–166, 201–206 and 313–318, 8 figs. Discusses application of heat engines to rail traction; different types of transmission, especially mechanical; mechanical transmission applied to high power; the Fieux friction make and break system; mechanical transmission in rail traction, etc.; speed changes for powerful engines, sliding double change-speed wheels; planetary gears; hydraulic transmissions.

Motor Rail Car Developments in the United States. Engineering, vol. 121, no. 3131, Jan. 1, 1926, pp. 25–27, 8 figs. Describes types of cars which have been developed.

Gasoline. New Type Motor Rail Car Introduced. W. W. Baxter. Ry. Rev., vol. 77, no. 22, Nov. 28, 1925, pp. 807–809, 2 figs. All-steel construction with two engines driving both trucks employed in new unit for branch lines; built by Smalley Rail-Car Co. at Davenport, Ia. See also description in Ry. Age, vol. 79, no. 24, Dec. 12, 1925, pp. 1183–1185, 4 figs.

Gasoline-Electric. Brill Gas-Electric Car Has Simple Control, Geo. E. Boyd. Ry. Rev., vol. 77, no. 26, Dec. 26, 1925, pp. 939–942, 5 figs. Self-contained unit, designed for either multiple or double-end operation, has high tractive capacity; power equipment consists of specially designed Brill-Westinghouse Model 250 six-cylinder 250-hp. gasoline engine, direct connected to 160-kw. Westinghouse d.c. generator.

Gas Electric Drive Applied to McKeen Cars, E. Wanamaker. Ry. Elec. Engr., vol. 16, no. 12, Dec. 1925, pp. 379–383, 7 figs. Rock Island equips three with electromotive power units at Horton shop at cost of $70,000.

Switzerland. The New Motor Coaches of the Montreux-Bernese Oberland Railway. Brown Boveri Rev., vol. 12, no. 12, Dec. 1925, pp. 262–271, 10 figs. Details of new Brown Boveri combined passenger and freight type of motor coaches, each motor having capacity of 100 tons for 0.7-per cent gradients, 55 tons for up to 4-per cent gradients and 40 tons for up to 7.2-per cent gradients, using 620 to 650 volts; motors are self-ventilating; coaches are provided with vacuum-brake equipment.

RAILWAY OPERATION

Economics. Economics of Railway Operation. Am. Ry. Eng. Assn.—Bul., vol. 27, no. 278, Aug. 1925, pp. 66–80. Report of committee covering method for determining allowance for maintenance-of-way expenses due to increased dues and increased investments, including items chargeable to roadbed and track accounts, also bridges and buildings.

Train Speed, Checking. Checking Train Speeds (Ueberwachung der Zuggeschwindigkeit), E. Besser. Organ für die Fortschritte des Eisenbahnwesens, vol. 80, no. 19, Oct. 15, 1925, pp. 400–402, 4 figs. Describes method and apparatus for recording speed of trains passing a given section of 50 m. in length; measured by length of a strip of paper of a Morse writer pulled during the interval; of special use for checking pull-up at danger signals.

RAILWAY REPAIR SHOPS

Locomotive. Maintenance of Motive Power on New England Railways, E. Sheldon. Am. Mach., vol. 64, nos. 2, 4 and 5, Jan. 14, 28 and Feb. 4, 1926, pp. 39–42, 151–155 and 203–206, 32 figs. Practice at locomotive shop of New York, New Haven & Hartford R.R. at Readville, Mass. Jan. 14: Layout of shop and arrangement of equipment; how materials are handled; journals and driving boxes; two methods of turning crown brasses; casting hub liners; driving-box chuck. Jan. 28: Machining shoes and wedges; motion work; time- and labor-saving devices. Feb. 4: Main and side rods; oxyacetylene profile cutting machine.

RAILWAY SHOPS

Equipment and Methods. The Elizabeth Shops of the Central R.R. of New Jersey, S. Ashton Hand. Am. Mach., vol. 63, no. 27, Dec. 31, 1925, pp. 1051–1053, 10 figs. Making taper frame bolts; tool-lifting device for planer; planing crossheads; tool for truing cylinder ends; large work in turret lathe.

Steel-Car Building. E. J. & E. Steel Car Shop at Joliet. Ry. Mech. Engr., vol. 99, no. 12, Dec. 1925, pp. 769–773, 8 figs. Describes shop method of organizing to rebuild 12 composite gondolas a day.

RAILWAY SIGNALING

Chicago Union Station. Signals and Interlockers in the Chicago Union Station, T. Holt. West. Soc. of Engrs.—Jl., vol. 30, no. 11, Nov. 1925, pp. 489–500, 7 figs. Description of 2 signal systems, one of 6 approach tracks serving 14 station tracks, and other of 4 approach tracks serving 10 station tracks; power-distributing systems; interlocking towers and machines.

Colored-Light Automatic Block. N. C. & St. L. Installs 136 Miles of Color-Light Automatic Block, Geo. S. Pflasterer. Ry. Signaling, vol. 18, no. 12, Dec. 1925, pp. 453–457, 17 figs. A.c. primary power-supply system, with electric switch lamps, parkway cable and special signals at switches are features on installation made by road.

RAILWAY STATIONS

Chicago. Chicago Union Station, J. D'Esposito. West. Soc. of Engrs.—Jl., vol. 30, no. 11, Nov. 1925, pp. 447–460, 10 figs. Discusses group of structures and improvements including buildings, tracks, viaducts, freight and mail-handling installations, etc., generally known as Chicago Union Station Project, now practically completed and in operation.

RAILWAY SWITCHES

Remote-Control. C. B. & Q. Controls Switches Remotely. Ry. Signaling, vol. 18, no. 12, Dec. 1925, pp. 460–462, 8 figs. Distant ends of passing tracks and junction switches operated electrically, eliminating train stops.

RAILWAY TRACK

Ballast Cleaning. Vacuum Cleaner Renovates Ballast on Pennsylvania Ry. Age, vol. 79, no. 26, Dec. 26, 1925, pp. 1195–1196, 2 figs. Vacuum cleaner of such size and power that it is capable of lifting stone ballast and foreign matter embedded in it from track to cleaning chamber mounted on car has been employed in renovating ballast on Philadelphia division of Pennsylvania. See also description in Ry. Eng. & Maintenance, vol. 21, no. 12, Dec. 1925, pp. 495–496, 2 figs.

Stresses. Special Committee on Stresses in Railroad Track. Am. Ry. Eng. Assn.—Bul., vol. 26, no. 275, Mar. 1925, pp. 1081–1245, 103 figs. Details of conduct of tests and production data; straight and curved tracks, stresses in rails, vertical and lateral stresses in curved track; test carried out in Chicago, Milwaukee and Eastern Rys.

RAILWAYS

Changing Problems and I. C. C. Changing Problems of Railways and I. C. C., F. J. Lisman. Ry. Age, vol. 79, no. 26, Dec. 26, 1925, pp. 1204–1206. Consolidation; motor buses and trucks; long and short-haul clause; rates; valuation.

REAMERS

Floating Cutters. Adjustable Reamer with Floating Cutters. Engineering, vol. 120, no. 3129, Dec. 18, 1925, p. 779, 3 figs. Describes reamer brought out by D. Brown & Sons, Huddersfield; two short, diametrically opposed cutters of rectangular section are employed. See also Machy. (Lond.), vol. 27, no. 69, Dec. 24, 1925, pp. 422–423, 5 figs.

REFRACTORIES

Boiler Furnaces. Refractories Service Conditions in Boiler Furnaces, R. A. Sherman. Power, vol. 63, no. 3, Jan. 19, 1926, pp. 113–115, 5 figs. Manufacturing and service conditions; furnace and refractories temperature; slags and refractories; use of slag screens; spalling. (Abstract.) Paper read before Am. Refractories Inst.

Use of Plastic Refractories in Boiler Furnaces, H. E. Weightman. Power, vol. 63, no. 3, Jan. 19, 1926, pp. 90–93. Practical hints on use of plastic refractories.

construction of walls and arches, instructions on initial firing and cooling, characteristics of various plastics, and cost and service compared to brick.

REFRIGERATING MACHINES

Two-Stage. Two-Stage Marine Cooling Machines with Intermediate Cooling. Ice & Cold Storage, vol. 28, no. 333, Dec. 1925, pp. 317–319, 2 figs. Discusses new method based on practical use of two-stage compressor in combination with simple mixed cooling, in an intermediate bottle-shaped vessel, which serves to absorb and draw off cold medium that becomes liquid, assisted by process in general use and protected by Linde Ice Machines Co. (Translated from Werft und Reederei).

Types. Automatic Refrigerating Machines (Automatiske kölemaskiner), Andersen. Tekniske Forenings Tidsskrift., vol. 49, no. 11, Nov. 1, 1925, pp. 185–195, 19 figs. Details of principle and construction of compression and absorption machines, Güttner type of compressor; ice generators; application of cooling in various industries, including slaughter houses, chocolate factories; household types.

RESEARCH

Industrial. Industrial Picture through the Focus of Research, M. Holland. Am. Welding Soc.—Jl., vol. 4, no. 11, Nov. 1925, pp. 12–17. Development of growth of research in industries, and the part governments, national research council, and other bodies are taking in it.

Pure-Science. The Vital Need for Greater Financial Support to Pure-Science Research, Herbert Hoover. Mech. Eng., vol 48, no. 1, Jan. 1926, pp. 6–7. Points out that United States is backward in development of research in pure science; scientific work seriously impeded by lack of financial resources; need of adequate organized financial support to pure science recognized by leaders of industry.

RIVETED JOINTS

Tests. Comparative Tests of Button Head and Countersunk Riveted Joints, J. B. Kommers. Univ. Wis.—Bul., vol. 9, no. 5, 59 pp., 10 figs. Method and apparatus for testing comparative strength of buttonhead and countersunk rivets, etc.; concludes that average ultimate shearing strength of countersunk joints is at least equal to that of buttonhead joints for lap, single-covered butt and double-covered butt joints; for lap joints diameter of rivet and thickness of plate seem to have little effect on ultimate shearing strength of rivets; deformation, and results of bending tests.

ROLLING MILLS

Billet Mill. The Removal of Scale during Rolling, F. L. Estep. Forging—Stamping—Heat Treating, vol. 11, no. 12, Dec. 1925, pp. 425–426, 2 figs. Discusses defects appearing in finished product which are often traceable to metallurgical practice, condition of molds, soaking pits, reheating furnaces, etc.

Electric Drive. Electrical Rolling Mills, D. W. Blakeslee. Iron & Steel Engr., vol. 2, no. 12, Dec. 1925, pp. 508–512, 17 figs. Discusses finishing mills, bar mills, rod mills, method of electric drive, power consumption, etc.

Selection of Electric Drives for Reversing Mills, L. A. Umansky. Iron & Steel Engr., vol. 2, no. 12, Dec. 1925, pp. 479–500, 21 figs. Shows how capacity of a contemplated reversing drive may be determined, what factors affect the size of the machines, and how they affect it; how the terms "horsepower," "torque," "ampere," etc., are related to each other in a reversing-mill equipment; gives new procedure for the rather simple calculations required and proves that these calculations very closely approach actual test results.

High-Speed Cold. The High-Speed Cold Rolling Mill. Engineer, vol. 140, no. 3652, Dec. 25, 1925, pp. 688–691, 2 figs. Author believes that, now that application of roller bearings has been proved to be successful with cold-rolling mill, greatest obstacle in way of adoption of high rolling speeds has been removed.

Plate Mills. Complete Large Universal Plate Mill in Great Britain, Jos. Horton. Iron Trade Rev., vol. 77, no. 27, Dec. 31, 1925, pp. 1643–1646 and 1656, 5 figs. Details of plate mill placed in operation at Moss End works of Stewart & Lloyds, Clydesdale, Glasgow, Scotland.

Steel-Rolling Practice. The Theory and Practice of Rolling Steel, W. Tafel. Iron Trade Rev., vol. 77, nos. 12, 13, 14, 15, 16, 17, 19, 21, 23, 25 and 27, Sept. 17, 24, Oct. 1, 15, 22, Nov. 5, 19, Dec. 3, 17 and 31, 1925, pp. 677–679, 739–741, 824–825, 964–966, 1033–1036, 1143–1146, 1277–1280, 1404–1405 and 1434, 1530–1533 and 1651–1655, 65 figs. Important theories and rules of rolling; characteristics of rolling process; notch test; guides; excess over draft increases stress; roll diameter affects grip; roll-pass design.

S

SCREW MACHINES

Collet Adapters for. Collet Adapters for Screw Machines, H. Simon. Machy. (N. Y.), vol. 32, no. 5, Jan. 1926, p. 384, 1 fig. Describes feeding finger and collet-adapter set, which, at small expense, not only offers simple way of putting idle equipment to work and avoiding unnecessary outlay of money for equipment, but also gives quick relief in many cases where trouble and delay would otherwise occur.

SEMI-DIESEL ENGINES

Horizontal Crude-Oil. Horizontal Crude-Oil Engines. Engineering, vol. 121, no. 3123, Jan. 8, 1926, p. 42, 3 figs. Details of semi-Diesel general-purpose engines made by Babcock P. Wilcox, London; crankcase compression is employed.

Ignition Plug for. Ignition Plug for Semi-Diesel Engines. Engineering, vol. 120, no. 3130, Dec. 25, 1925, p. 817, 1 fig. Plug designed by Lodge Plugs, Ltd., Rugby, Eng., for igniting oil spray until some part of combustion chamber becomes sufficiently hot to maintain ignition.

SHAFTS

Whirling Speed of Drum Rotors. Whirling Speeds of Drum Rotors, T. M. Naylor. Engineer, vol. 141, no. 3656, Jan. 22, 1926, p. 89, 4 figs. From experiments and calculations, it is concluded that if drum rotors are "massed up" and Dunkerley's expressions used, very close approximations to whirling speeds will be obtained.

SHAPERS

Gear-Cutting Attachments. Gear Cutting Equipment for Shaping Machines. Engineering, vol. 121, no. 3131, Jan. 1, 1926, pp. 11–14, 12 figs. Gear-cutting attachments introduced by Matterson, Ltd., Shawclough, Rochdale, in which single straight tool is employed; this tool is ordinary V-type.

SHEARS

Bar. Multiple Bar-Shearing Machine. Engineer, vol. 141, no. 3656, Jan. 22, 1926, pp. 104–105, 4 figs. partly on p. 100. New shearing machines, constructed by De Bergue & Co., Manchester, Eng., consisting of a substantial bed of box section, provided with planed guides for reception of sliding saddles, which carry bottom shear blades, and two massive standards, secured by means of bolts to top surface of bed.

STANDARDS

U. S. Bureau of Standards, Report. Annual Report of Director of the Bureau of Standards for Fiscal Year Ended June 30, 1925. U. S. Bur. of Standards—Miscl. Publications, no. 69, 1925, 41 pp. Details of its activity during fiscal year, covering weights and measures, electricity, heat and power, optics, chemistry, mechanics and sound, structural engineering, metallurgy, ceramics, simplified practice, building and housing, etc.

National Bureau of Standards. U. S. Bur. of Standards—Circular, no. 1, Oct. 29, 1925, 111 pp., 86 figs. Report on purposes and activities of Bureau of Standards and details of work carried out in scientific and industrial research, testing standards and specifications, simplified practice, etc.

Welding. Concepts and Designations in the Field of Welding (Begriffe und Bezeichnungen auf dem Gebiete der Schweisstechnik), G. Hilpert. Autogene Metallbearbeitung, vol. 18, no. 20, Oct. 15, 1925, pp. 305–308, 3 figs. Discusses definitions of terms and formulation of standards for designating types of fusion, electric arc and resistance welding, welded joints, etc.

STEAM

High-Pressure. High Pressure Steam (Hochdruckdampf), P. Wangemann. Feuerungstechnik, vol. 14, no. 1, Oct. 1, 1925, pp. 1–3. Discusses possible developments of boilers of 30–100 atmos. for large capacities and so-called waterless boilers for small capacities; prospects for each, and experimental work required.

High Pressures and Temperatures. High Steam Pressures and Temperatures. Power Plant Eng., vol. 30, no. 2, Jan. 15, 1926, pp. 131–133, 3 figs. High-steam pressures and temperatures bring greater economy but limits are fixed by properties of materials available. (Abstract.) Report of Prime Movers Committee of N.E.L.A.

Specific Heat at High Pressures. Graphical Representation of the Specific Heat of Steam at High Pressures, Schmolke. Mech. Eng., vol. 48, no. 1, Jan. 1926, pp. 63–64, 10 figs. Points out that with modern tendency toward commercial employment of high steam pressures, knowledge of thermodynamic properties—especially specific heat—of steam at higher ranges becomes of great importance; describes method of calculation. Translated from Wärme, vol. 48, Aug. 21, 1925.

STEAM ACCUMULATORS

Installation in Steam Plant. Industrial Plant to Install Steam Accumulator. Power, vol. 62, no. 26, Dec. 29, 1925, pp. 1013–1014, 1 fig. New arrangement of steam lines in power plant; accumulator, which is of Ruths type, is designed to take care of all fluctuations in consumption of steam occurring during normal operation in any part of refinery; this will allow boilers to be operated at practically constant rating, which is expected to give much higher overall efficiency.

Principle of. Steam Accumulators, A. J. T. Taylor. Combustion, vol. 13, no. 5, Nov. 1925, pp. 275–277, 2 figs. A discussion of principle upon which they are based and of their importance to heat-using industries.

STEAM ENGINES

Breakdowns. Engine Breakdowns, Johnstone-Taylor. South. Engr., vol. 43, no. 10, Dec. 1925, pp. 46–48, 5 figs. Deals with cylinder failures, piston and rod failures and flywheel explosions.

Metallic Packing for. A New Metallic Packing (Was verlangt die Wärmewirtschaft und Sicherheit im Dampfmaschinenbetrieb), A. Wrede. Bergbau, vol. 38, no. 44, Oct. 29, 1925, pp. 698–699, 1 fig. Rexim metallic packing, marketed by Düsseldorf, Germany, firm, is said to offer number of advantages, particularly maintenance of steam-tight joint, notwithstanding considerable freedom of movement; according to requirements, each ring is divided into 4 or 6 pieces; experience shows that transverse freedom possessed by this type of packing enables tight joint to be maintained on rods, line of travel of which does not coincide with their axis.

Types and Applications. The Steam Engine as a Factor in Industrial Power. Power, vol. 63, no. 1, Jan. 5, 1926, pp. 16–17. Special investigation shows trends in types and applications to industries; figures show steam engine holding its own.

STEAM GENERATORS

Pulverized-Coal-Burning. Steam Generator of Unique Design Gives High Rating. Power Plant Eng., vol. 30, no. 2, Jan. 15, 1926, p. 157. Combustion Steam Generator, recently placed on market, combines recent developments of pulverized fuel, water-cooled furnace wall, preheated air and turbulent action in combustion space; practically all boiler surface is exposed to radiant heat.

STEAM METERS

Zelenka. Volume Meter for Flowing Liquids and Gases (Mengenmesser für strömende Flüssigkeiten und Gase), O. Böhm. Zeit. des Vereines deutscher Ingenieure, vol. 69, no. 49, Dec. 5, 1925, pp. 1523–1526, 13 figs. Describes steam meter developed by O. Zelenka which can be used for measurement of liquids, gases and vapors; principle upon which design is based, and advantages of meter.

STEAM POWER PLANTS

Design Developments. Power Station Design Continues to Progress, P. Junkersfeld. Power Plant Eng., vol. 29, no 24, Dec. 15, 1925, pp. 1248–1250, 1 fig. Interconnection of generating stations presents new problems to designers; B.t.u. required per kw-hr. cut to 16,000 in 1925.

High-Pressure. 800-Hp. High-Pressure Installation in the Power Plant of A. Borsig (800 PS-Hochdruckanlage in der Kraftzentrale bei A. Borsig G.m.b. H., Berlin-Tegel), M. Hochwald. Elektrotechnische Zeit., vol. 46, no. 44, Oct. 29, 1925, pp. 1647–1648, 5 figs. Thermo-economic advantages of maximum-pressure steam, especially back-pressure operation; describes Borsig plant and gives results of tests.

Higher Steam Pressures in Industrial Plant, Wm. F. Ryan. Mech. Eng., vol. 48, no. 1, Jan. 1926, pp. 43–47, 6 figs. Shows that gains from high pressure are greater in industrial plant than in central station, and that except for question of suitable feedwater for high-pressure boilers, problems involved are less difficult; estimates relative cost of power for varying initial pressure; relative efficiency of turbine and engine prime movers, and application of higher pressures to manufacturing equipment. (Abridged.)

Pneumatic Sweeping Systems. Pneumatic Sweeping Systems in Power Plants, F. C. Allen, Jr. Power Plant Eng., vol. 30, no. 2, Jan. 15, 1926, pp. 147–148, 2 figs. Broom sweeping is inadequate and dust-explosion hazard makes suction systems desirable.

Wood-Refuse Burning. Wood Refuse Burned on Underfeed Stoker, C. M. Garland. Power, vol. 63, no. 2, Jan. 12, 1926, pp. 46–49, 5 figs. Modern 1300-kw. turbine plant of Graham Bros. at Evansville, Ind., operated non-condensing to meet demand for heating and process steam; with cheap fuel, boiler room is of simple design; either bituminous coal or wood refuse is burned on underfeed stokers; system of handling wood refuse provides safety and flexibility.

STEAM TURBINES

Design. Graphical Design of Steam Turbines, A. Oppitz. Mech. Eng., vol. 48, no. 1, Jan. 1926, pp. 60–61, 8 figs. Author attempts to apply to turbine design the comparatively newly developed method of applied mathematics, namely, nomography. (Abstract.) Translated from Archiv für Wärmwirtschaft, vol. 6, Oct. 1925.

Steam Turbine Growth Steady. Power, vol. 63, no. 1, Jan. 5, 1926, pp. 12–15, 4 figs. Large-capacity units; higher steam pressure and temperature; high-economy small units; continued refinements in design; large condensers and new designs installed; valves and piping show progress.

Efficiency of Blading. The Efficiency of Reaction Blading. Engineering, vol. 120, no. 3129, Dec. 18, 1925, pp. 775–776, 1 fig. Refers to test results on Brown-Boveri steam turbine, described by Prof. Stodola in same journal, Oct. 2, 1925; and discusses figures somewhat more fully than was done in report; explanation of term, hydraulic efficiency.

Oerlikon. Improved Steam Turbines. Engineer, vol. 141, no. 3656, Jan. 22, 1926, pp. 105–107, 9 figs. Comparison of Oerlikon turbines constructed at various dates, installed in Wood-lane Station of Kensington & Notting Hill Elec. Lighting Co.; efficiency curves and tables.

Overhauling. Overhauling the Main Turbines at Connors Creek. Power Plant Eng., vol. 30, no. 2, Jan. 15, 1926, pp. 135–136, 4 figs. All of turbines in Detroit Edison plant, which is about 10 years old, have been entirely overhauled and rebuilt.

STEEL

Alloy. See ALLOY STEEL.

Cold-Worked. Thermal Disturbances and Recrystallization in Cold-Worked Steels, V. N. Krivobok. Am. Soc. Steel Treating—Trans., vol. 8, no. 6, Dec. 1925, pp. 703–720, 20 figs. If metals, from 0.50-per cent carbon steel down to Armco iron are worked at room temperature and subjected to thermal analysis, they all show evolution of heat, below critical range, this evolution creating on critical curve a point similar in every respect to standard critical points, but opposite in sign; it is arbitrarily designated the "Ax" point; Ax point is not of reversible type; it seems reasonable to assume that it indicates both recrystallization and relief in internal strains; conclusions are based on actual observations during thermal analysis.

Hardened, Testing. Hardness Testing of Hardened Steel (Die Härteprüfung von gehärteten Stahlen), Mailänder. Kruppsche Monatshefte, vol. 6, Oct. 1925, pp. 204–208, 5 figs. Shows that in determining